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MANGROVE ECOSYSTEMS

A MANUAL FOR THE ASSESSMENT OF BIODIVERSITY

A follow up of the
National Agricultural Technology Project
(NATP.), ICAR.

Mangrove Ecosystem Biodiversity :
Its Influence on the Natural Recruitment of
Selected Commercially Important Finfish and Shellfish
Species in Fisheries

Edited by :
Dr. George J. Parayannilam

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Central Marine Fisheries Research Institute
(Indian Council of Agricultural Research)
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Zooplankton Fauna

T. S. Naomi, Ansy Mathew, George J. P., Sunirmal Giri and M. Kaliamoorthy

The zooplankton population consists of minute animals living freely in water with limited powers of locomotion and is more or less drifted passively by water currents. Almost every major group of animals, either as adults, larvae or as both has its representatives in planktonic existence. Many of the commercially important prawns, mussels, other shellfishes and finfishes start their life as plankters. The communities of zooplankton form the vital intermediary link in the food chain of the sea both as consumers of the primary producers and as contributors to the higher trophic level. Many species are proven indicators of pollution, water mass, cold, warm, surface or deep waters, upwelling characteristics and of the coastal or estuarine environment depending on the time of their occurrence and the ambient ecological parameters. Many are the holoplankters spending their entire life-cycle as plankters while some others like the eggs and larval stages of fishes, polymorphic forms such as hydroid medusae, occasional visitors like the young mussels, post-metamorphic juveniles in accidental pelagic state due to stirring up of the bottom or crustaceans simply swimming for a while in the shallow water over the intertidal zone when the tide floods, constitute the meroplankton of temporary pelagic phase. Thus the zooplanktons in general are multispecific in occurrence in relation to the water movement, ecological characters, depth, season and the prevailing conditions of the environment.

The zooplankton component of the mangrove fauna has not yet been studied in detail barring a few occasional reports. Several species are known to have life-history characteristics that are finely tuned to the unique ecosystem. The rich biotic environment and the high detritus content tend to make the coastal mangroves of the Indian subcontinent highly productive life sustaining systems. The flora and the vertebrate fauna of the mangroves received much attention in the past compared to the micro and macro fauna which are poorly understood even when the environment happens to be the known breeding ground for a variety of organisms. Three distinct types of organisms are observed here namely the exclusive mangrove residents; the marine species and fresh water species the last two are frequent visitors to the environment. One specific community may overlap with the other habitat community freely and frequently as and when the need arises.

The scarcity of specific information on the identity of the species of zooplankton fauna of the mangroves is a serious drawback. Adequate diagrams of certain common planktonic as well as non-planktonic animals followed by simple descriptions taken from published accounts are given wherever possible in the following pages. The uniqueness of the system and its varied inhabitants necessitate such a bold step so as to include the permanent and the temporary residents who have every chance to turn up at one time or the other in the planktonic collections due to tidal effects or any other disturbance which might come in their way of life.

Method of Collection

Scoop-net bucket method is effectively used in surf/mangrove/swamps for the collection of zooplankton. The principle is to filter a known

quantity of water (minimum 1 m^3 of water which is equivalent to 100 buckets of water drawn with a bucket of 10 litre capacity) through a scoop net (Mathew, 1998). The scoop net has a ring of 30 cm diameter made of a 12 mm aluminium rod. The ring is made in such a way that the two ends of the rod extend as a handle for holding the net. A net cone of 75 cm length tapering towards the cod end is attached to the ring. A plankton collection bucket is also fixed to the code end of the net with a window of the same net material. Appropriate lengths of 12.5 cm width of khaki cloth material are needed to attach the net cone to the net ring and the plankton collection bucket to the code end. Complete filtration of water is possible through the net and even bolting silk of smaller mesh sizes can be used as the net fabric to ensure the capture of tiny larval forms. For collecting a sample two persons go walking to the station and while one is holding the net slightly above the surface of water, the other person takes a 10-litre bucket full of water and pour it into the scoop net. The taking and pouring of water should be made as fast as possible to prevent the possibility of any plankton escaping the capture. The agitation caused in the water column will confuse the animals and in the process of haphazard movements the chances of escaping are brought to the minimum during the collection. The samples should be collected as early as possible in the morning hours.

Preservation

The net is washed after each collection by jet action of seawater to the outer sides of the net and thus the plankton sticking to the sides of the net is brought down to the collecting bucket. When the excess water is drained off the net through the window of the plankton collection bucket it is removed from the net and the plankton in sea water is poured into a wide mouthed polythene bottle of 500 ml capacity up to 375 ml. Commercial (40 %) formaldehyde solution is added in such a way so as to make the preservation 5 % strong. (50 ml commercial formalin and 25 ml sodium borate as buffer to 1000 ml plankton in seawater). One label on good quality paper is made in pencil or Indian ink showing the details such as the station number or name, date, time, type of collection and depth of the station and placed above the inner lid of the bottle below the screw cap. Important details such as the station number, date and type of collection are also written with a permanent marker pen on the outside of the bottle directly.

Volume of Water Filtered

Whenever there was some difficulty in filtering 1 m^3 of water the net was dragged above the bottom sediments without disturbing the mud for a known length of 100 m. The calculation is then based on the length of tow and the mouth area of the net ($\pi r^2 h$). Clogging of the meshes might introduce an error into this calculation. A flow meter of digital type, Hydrobios is tied to the mouth of the net to know the volume of water filtered by the net. It is a small device with a propeller at one end and a small window on one side where the revolutions of the propeller are indicated in numbers. The number of revolutions made by the flow meter is used to calculate the quantity of water filtered by the net in which it is used. The flow meter is calibrated at frequent intervals. The net fitted with the flow meter is lowered vertically to a known depth by releasing a known length of wire rope and hauled up at the rate of 1 m per second for the purpose of calibration. The number of revolutions made by the flow meter during the haul is noted. The net can also be used in a horizontal haul to record the number of revolutions made by the flow meter for a known distance. The volume of the water column through which the net travelled is then calculated using the formula $\pi r^2 h$ where r is the radius of the mouth ring and h is the known depth or the horizontal distance. By using the volume of water column and the number of revolutions made by the flow meter for filtering one cubic meter of water, the volume of water that can be filtered in one revolution is found out. This is the calibration factor that is used to multiply the number of revolutions made at each haul for a

particular station to calculate the volume of water filtered by the net.

Volumetric Analysis

The wet displacement method is used for the determination of the plankton volume. The volume determiner is a transparent cylindrical plastic apparatus of 100 ml capacity with both ends open. One end is fixed with a piece of netting of the same mesh size used for the plankton net and it can be fixed watertight over its plastic base. On the other end is a removable lid of plastic with a side hole. From the center of the lid hangs a metallic pointer needle which would reach up to the 50 ml mark made on the cylinder when the lid is fixed over the apparatus.

The preserved plankton is poured into the volume determiner. The water filters out and the interstitial water remaining in the plankton is removed by placing the cylinder over a blotting paper repeatedly till the water gets completely run out. The cylinder with the plankton is fixed watertight over its base. Adequate quantity of 5 % formaldehyde solution is slowly let out from a 50 ml burette inserted through the side hole of the lid of the apparatus without any air bubbles till the water level just touches the pointer of the lid. The level of solution remaining in the burette is equivalent to the volume of plankton in the cylinder. The volume of plankton per 100 m^3 of water filtered can be estimated after calculating the quantity of water filtered by the net during sampling.

Zooplankton Sub-sampling

A minimum quantity of 5 ml of plankton as determined by the wet displacement volume method is analysed for groups and species to get adequate representation. If the total volume is more than 5 ml the sample is sub sampled using a device Folssom Splitter. It is used to divide a sample into two equal halves at a time.

Sorting and Counting

The sub-sampled plankton is analysed fully either by sorting out or enumerating the constituents in a plankton counting chamber after identification under a stereoscopic binocular microscope. The sorted plankton groups are further analysed to the species level.

Labelling and Packing

The sorted groups or species are packed in small glass vials of appropriate sizes decided by the quantity of material to be packed. Preservation liquid is filled to the brim of the vial. A label indicating the sampling details and the name of the group or species is inserted into the vial and then plugged tightly with cotton without any air bubbles. All the vials pertaining to a group or species from the stations of a region are packed in a wide mouthed plastic jar after placing sufficient quantity of cotton at the bottom of the jar to prevent accidental breakage of the vials. The remaining space in the jar is also packed with cotton so that the vials will not be broken during transportation. Preservation liquid is poured to the brim of the jar. One label with full details is placed above the inner lid and another is pasted on the outside of the jar.

Plankton Data Base

A register is kept ready for entering the zooplankton data after analysing the samples incorporating details of area and collection method, species identification, enumeration and volume quantified per 100 m^3. Thus the database of zooplankton collections from a particular region or ecosystem is maintained for further treatment of the data.

FAUNISTIC COMPOSITION OF THE MANGROVE ECOSYSTEM

Kingdom **ANIMALIA**

Phylum **ARTHROPODA**

Subphylum **CRUSTACEA** Brunnich, 1772

Class **MAXILLOPODA** Dahl, 1956

Subclass **COPEPODA** Milne-Edwards, 1840

Infraclass **NEOCOPEPODA** Huys & Boxshall, 1991

Superorder **GYMNOPLEA** Giesbrecht, 1882

Order **CALANOIDA** Sars, 1903

The recorded copepod crustaceans from the mangrove ecosystem are regrouped as per the updated classification of the recent crustacea by Martin and Davis (2001). Accordingly, the infraclass Neocopepoda is divided into two superorders Gymnoplea Giesbrecht, 1882 and Podoplea Giesbrecht, 1882. The order Calanoida Sars, 1903 is thus grouped under the superorder Gymnoplea while the other three orders Cyclopoida Burmeister, 1834, Harpacticoida Sars, 1903 and Poecilostomatoida Thorell, 1859 are kept under the superorder Podoplea.

Copepod crustaceans in general are small in size and the body is divisible into head, thorax bearing biramous (paired) appendages and abdomen devoid of any appendages. The head and thorax merging smoothly to form a fore-body, a shell fold or carapace is absent, a simple median or nauplius eye with three ocelli although extra eyes occur in some species. A copepod is usually regarded as being built of a head comprising six segments-cephalosome, a thorax of six segments-metasome and an urosome or abdomen of four segments plus a telson or anal segment which bears the caudal rami or furca. Frequently, the first segment of the metasome is fused with the cephalosome, and /or the fourth and fifth segments of the metasome are fused. Thus, the metasome in some species may seem to have as few as three segments. The degree of fusion between segments is variable between the main suborders and the genital aperture is indistinguishably fused with the first abdominal segment in the female, while in the male these two segments remain separate. The cephalosome and metasome together are known as the prosome. There is no agreed system for the enumeration of copepod segments or for the names of appendages that they bear. The names of the appendages generally followed are for the head - antennules, antenna, mandible, maxilla and 1st maxilliped and for the thorax - 2nd maxilliped, 1st swimming leg, 2nd swimming leg, 3rd swimming leg, 4th swimming leg and 5th swimming leg. Diagrammatic illustrations on the external morphology and appendages of the copepods taken from Kasturirangan (1963), Newell and Newell (1977) and Mauchline (1998) are given in Figs.1; 2.a, 2.b, 2.c; 3, 4.1 & 4.2. The external appearance of a copepod often provides an important clue in identifying the various genera.

Among copepods, calanoids are the most numerous; primarily pelagic, 75% marine and the rest 25% live in fresh water. Some marine species are benthopelagic or commensal. The morphological characters of calanoids, cyclopoids and harpacticoids are shown in Fig.1; 2.a, 2.b & 2.c. The external features that distinguish the calanoids (Fig.1 & 2.a) from cyclopoids and harpacticoids are given below:

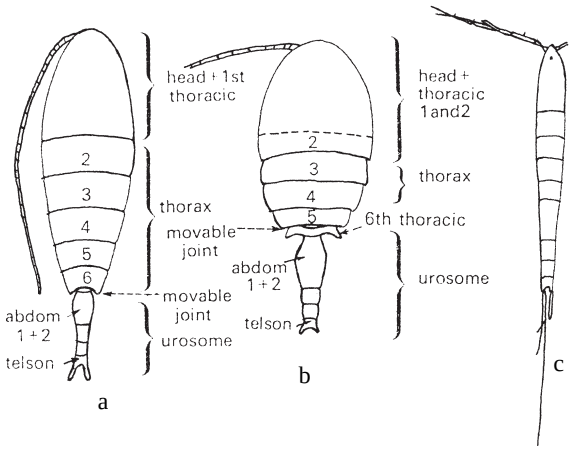

Fig. 1. Planktonic copepods-differences in the external morphology. (a) Female calanoid (b) Female cyclopoid (c) Female harpacticoid. (Newell & Newell, 1977)

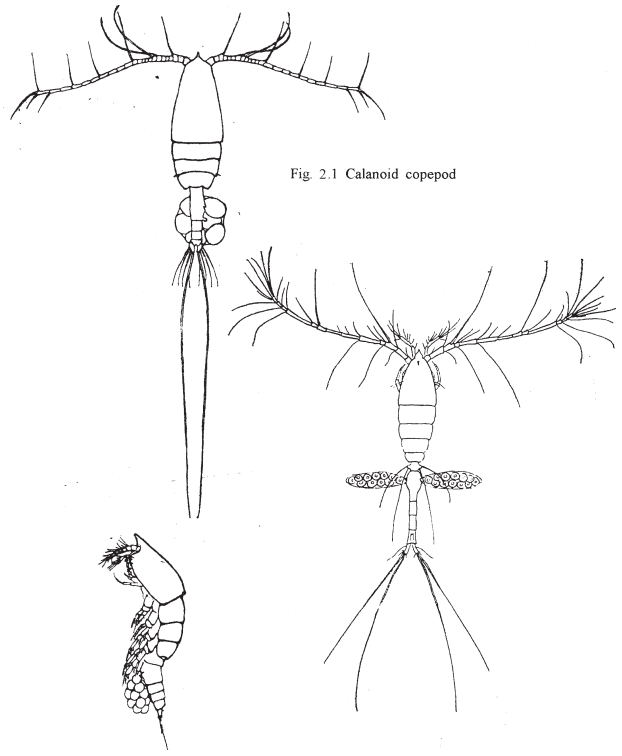

Fig. 2. External morphology of mature females (a) Female calanoid (b) Female cyclopoid (c) Female harpacticoid. (Kasturirangan, 1963)

- The antennules (1st antennae) are long and are composed of numerous segments or joints.
- The 2nd antennae are short.
- The body is not depressed and habits not ectoparasitic except in very rare cases.
- The metasome ends behind the segment of the 4th or 5th pair of legs.
- The eggs, except in a few genera, are carried by the female in a single cluster - not in paired egg sacs and always the eggs are shed freely into the water.
- The genital apertures (paired in the female and unpaired in the male) are borne on the first abdominal segment.
- The first antennae of the male, if geniculate, geniculate on one side only, commonly on the right side.
- The males of many species have one (either the left or the right) of the last pair of thoracic limbs modified as forceps in transferring the spermatophore to the female.

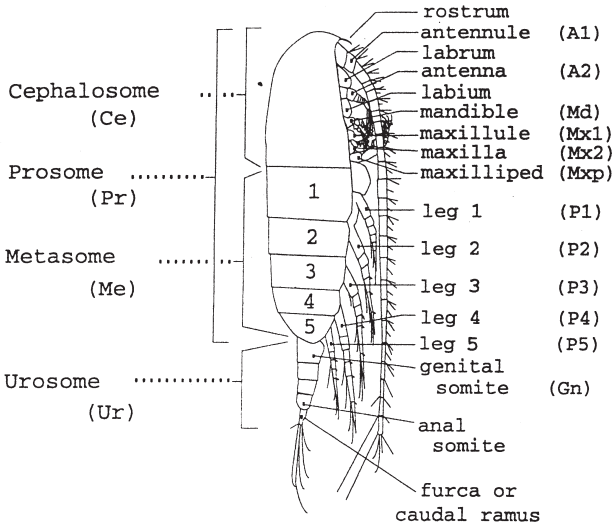

Fig. 3. Diagrammatic illustration of the external morphology and appendages of a female calanoid copepod (Mauchline, 1998)

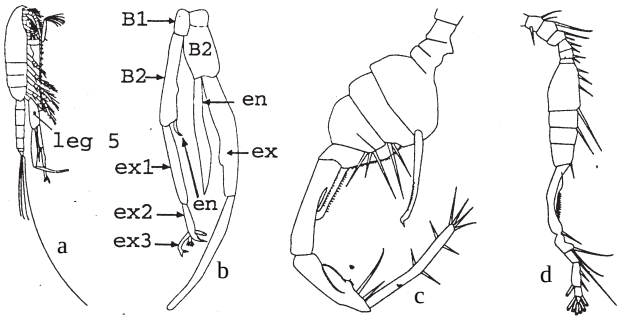

Fig. 4.1 Diagrammatic illustration of the external morphology and some appendages of a male calanoid copepod. (a) Male lateral view (b) Male 5th pair of legs (c) Male geniculate right antennule of *Pontella* species (d) Male geniculate right antennule of a *Candacia* species (Mauchline, 1998).

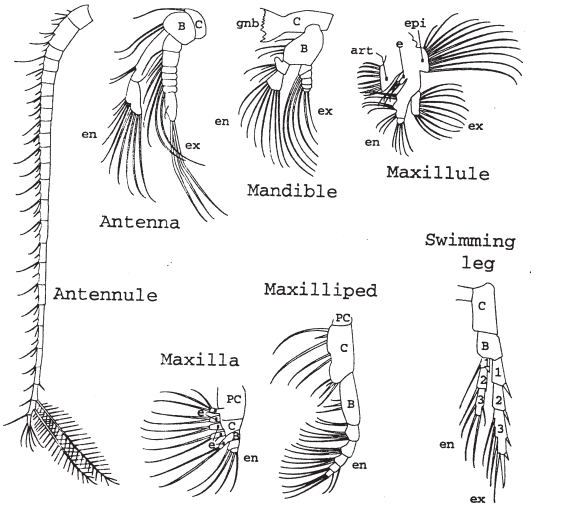

Fig. 4.2 Diagrammatic illustrations of the appendages of a calanoid copepod art-arthrite; B-basis; C-coxa; e-endite; en-endopod; epi-epipodite; ex-exopod; gnb-gnathobase; PC-praecoxa. (Mauchline, 1998).

Superorder **PODOPLEA** Giesbrecht, 1882

Order **CYCLOPOIDA** Burmeister, 1834

The cyclopoid copepods are divided between marine and fresh waters and can be pelagic, commensal or parasitic. The general characters (Figs.1 & 2.b) are:

- The body usually depressed with the metasome much wider than the urosome.
- The urosome consists of five segments in the female and six in the male plus a telson, but fused in some.
- The antennules (1st antennae) are short and have only a few joints.
- The egg sacs are paired in most species and carried laterally or subdorsally.
- The geniculation of the first antennae of the male is usual but not invariable.
- The basal segment of the 5th legs without an inner expansion.

Order **HARPACTICOIDA** Sars, 1903

The harpacticoids are primarily marine species, 10% living in fresh waters. The vast majority of harpacticoids are benthic, a few pelagic or commensal. Some are truly planktonic particularly in shallow seas with a sandy or muddy floor. The distinguishing features (Figs.1 & 2.c) are:

- The body usually cylindrical, the metasome passing into the urosome without any abrupt change in width.
- They are minute in size, majority less than 1 mm long.
- The egg sacs may be single or paired, usually unpaired and carried underneath.
- The antennules (1st antennae) are short, usually with less than six joints.
- The basal segment of the 5th legs usually showing an inner expansion.
- The males are distinguished from the females in all cases by the geniculation of the 1st antennae.

Order **POECILOSTOMATOIDA** Thorell, 1859

Three genera ***Corycaeus***, ***Oncaeus*** and ***Sapphirina***, which were recognized earlier under the order Cyclopoida, are exclusively marine and hence given a separate order Poecilostomatoida Thorell, 1859.

Order **CALANOIDA** Sars, 1903

Family **ACARTIIDAE** Sars, 1900

Genus ***Acartia***

Second antennae with two-jointed endopod in which the distal segment is almost as long as the proximal, posterior margin of the metasome drawn out into spines. **Females**: 5th legs always uniramous, slender and spine-like and urosome 3-segmented, 1st antennae alike on two sides. **Males**: urosome 5-segmented, 4th segment very short, 2nd largest of all, 1st with lateral genital aperture and 1st antenna on the right side is indistinctly geniculate. 5th legs uniramous.

1. *Acartia spinicauda* Giesbrecht **Female**: The spines of the metasome corners are smaller compared to ***A. erythraea*** and ***A. centrura***, terminal claw of 5th leg scarcely widened at base, straight, without notch and with serrations on distal half, length 1.0 to 1.3 mm; (Fig. 1.a, b & c).

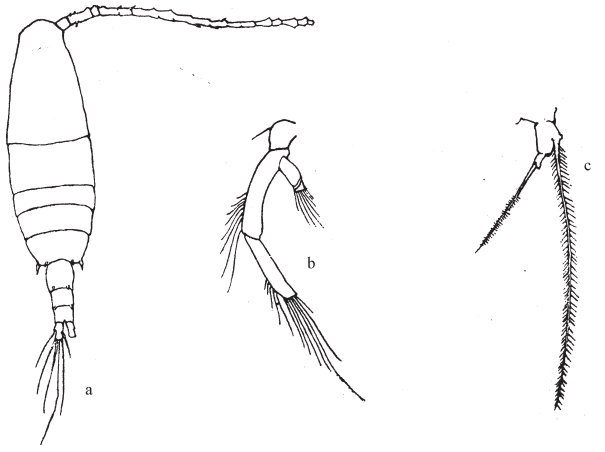

Fig. 1. *Acartia spinicauda* Giesbrecht (a) Female dorsal view. (b) Female 2nd antenna. (c) Female 5th leg. (Kasturirangan, 1963)

Male: The 2nd urosome segment with two pairs of spines, inner pair smaller than outer; spines on 3rd urosome segment are long and over-reach the very short 4th segment, length 1.0 to 1.2 mm; (Fig. 2.a & b).

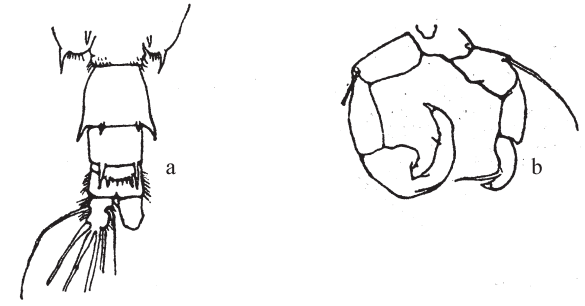

Fig. 2. *Acartia spinicauda* Giesbrecht (a) Male urosome dorsal view. (b) Male 5th pair of legs, anterior view. (Kasturirangan, 1963).

2. *Acartia erythraea* Giesbrecht **Female**: The 2nd urosome segment bears two small inconspicuous spines placed close together; terminal claw of 5th leg thickened a little at the base, curved, smooth, and without any notch, length 1.0 to 1.4 mm; (Fig.1.a & b).

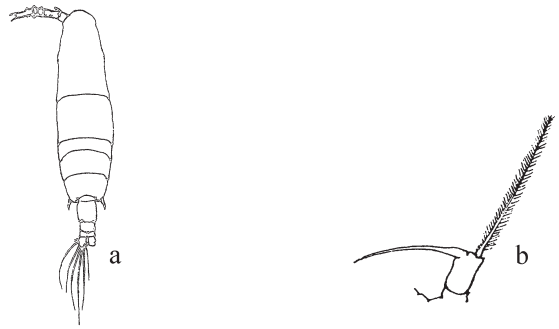

Fig 1. *Acartia erythraea* Giesbrecht. (a) Female dorsal view. (b) Female 5 th leg. (Kasturirangan, 1963).

Male: The 2nd urosome segment wider than long, with two pairs of prominent spines, inner pair as large as the outer; length 1.0 to 1.3 mm; (Fig. 2.a & b).

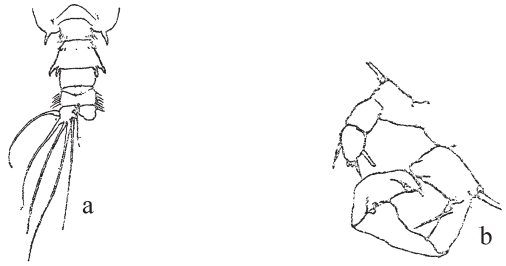

Fig. 2. *Acartia erythraea* Giesbrecht. (a) Male urosome. (b) Male 5th leg. (Kasturirangan, 1963).

3. *Acartia centrura* Giesbrecht **Female**: The 2nd urosome segment bears two spines that are comparable in size and position to the spines on the 1st urosome segment. The spines of the metasome corners are as large as in ***A. erythraea;*** terminal claw of 5th leg swollen at the base, smooth, straight and with a distinct notch; length 1.20 to 1.24 mm; (Fig.1.a & b).

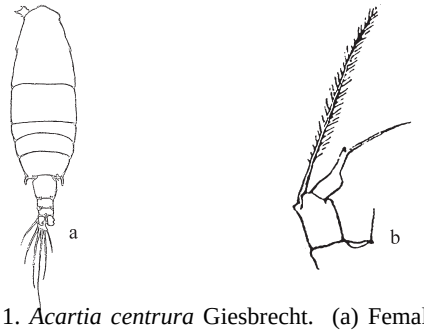

Fig. 1. *Acartia centrura* Giesbrecht. (a) Female dorsal view. (b) Female 5th leg. (Kasturirangan, 1963).

Male: The 2nd urosome segment with three pairs of spines, the two inner pairs quite small, the outer pair a little longer; spines on 3rd urosome segment do not fully overreach the 4th segment; length 1.02 mm; (Fig. 2.a & b).

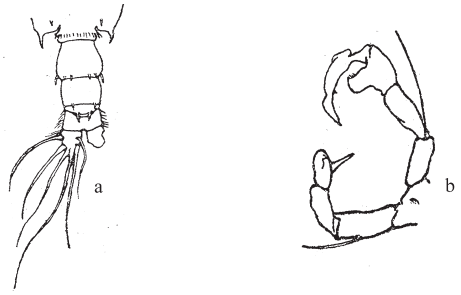

Fig. 2. *Acartia centrura* Giesbrecht. (a) Male urosome, dorsal view (b) Male 5th pair of legs anterior view. (Kasturirangan, 1963).

4. ***Acartia chilkaensis*** Sewell **Female**: Metasome posterior margin smooth or with minute spinules only; habitat estuarine and brackish water. 5th legs straight, with a notch as in ***A. centrura*** but set with short hairs on both margins; length 1.0 to 1.1 mm in both sexes; (Fig. 1.a, b & c).

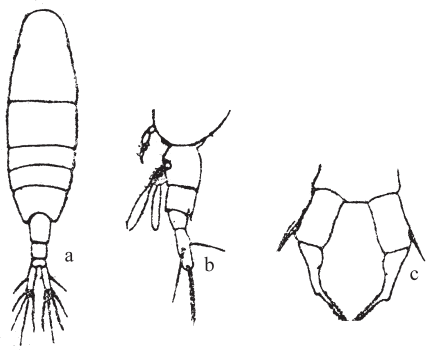

Fig. 1. *Acartia chilkaensis* Sewell. (a) Female, dorsal view. (b) -Female, urosome, lateral view. (c) Female, 5th pair of legs. (Kasturirangan, 1963).

Male: Same as in female. Length 1.0 to 1.1 mm; (Fig. 2.a & b).

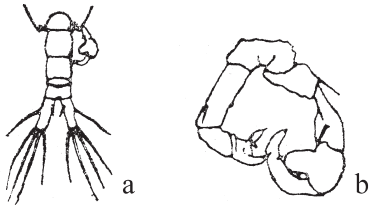

Fig. 2. *Acartia chilkaensis* Sewell. (a) Male, 5th pair of legs, posterior view. (b) Male, urosome and a part of metasome, dorsal view. (Kasturirangan, 1963).

5. ***Acartiella sewelli*** Steuer **Female**: Urosome 3-segmented, anal segment very short; right caudal ramus a little longer than the left, 5th legs biramous, length 1.38 to 1.57 mm; (Fig.1.a, b & c).

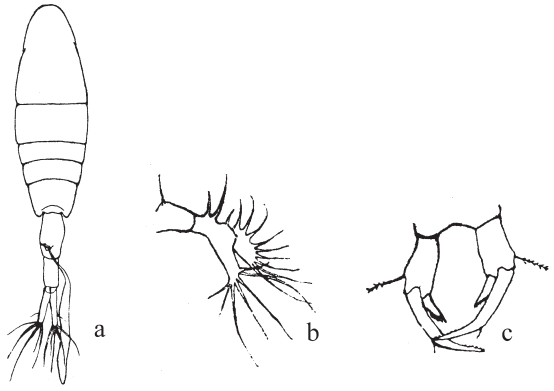

Fig. 1. *Acartiella sewelli* Steuer. (a) Female, dorsal view. (b) Female, 2nd antenna. (c) Female, 5th pair of legs. (Kasturirangan, 1963).

Male: Urosome 4-segmented, right caudal ramus longer than the left; this inequality is more pronounced in the male; right leg longer and with a short process arising from its basal segment; length 1.27 to 1.51 mm; (Fig. 2.a & b).

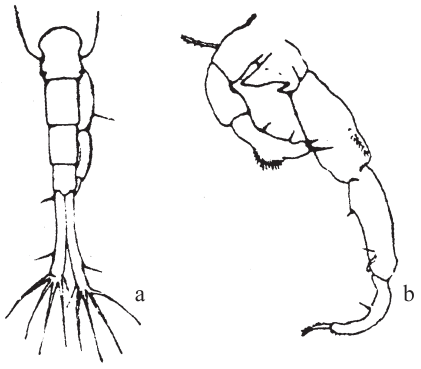

Fig. 2. *Acartiella sewelli* Steuer. (a) Male, urosome, dorsal view (b) Male, 5th pair of legs, posterior view. (Kasturirangan, 1963).

Family **CALANIDAE** Dana, 1846

Genus ***Canthocalanus***

Basipod of 1st legs with a hook and seta arrangement on the anterior face; inner margin of basipod 1 of 5th legs smooth in both sexes.

1. ***Canthocalanus pauper*** (Giesbrecht) **Female**: Urosome 4-segmented; exopodites of the 5th legs with plumose setae; length 1.7 mm; (Fig. 1. a, b & c).

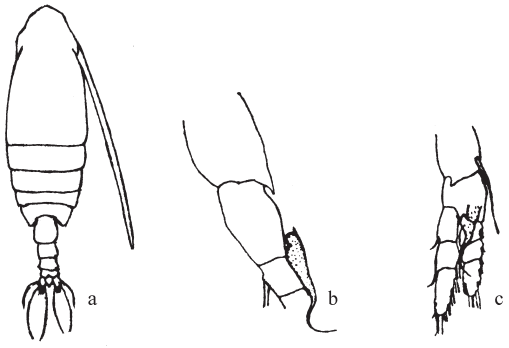

Fig. 1. *Canthocalanus pauper* (Giesbrccht). (a) Female, dorsal view. (b) Female, 1st leg, anterior face. (c) Female, 1st leg, lateral view. (Kasturirangan, 1963).

Male: Urosome 5-segmented; exopodites of the 5th legs without plumose setae; the left exopod often flexed outwards to assume a hammer-like form; left endopod with 2 terminal setae only; length 1.4 mm; (Fig. 2. a, b, c & d).

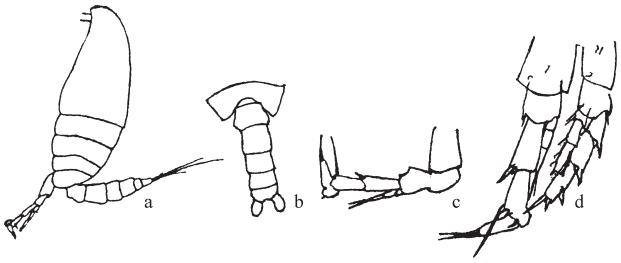

Fig. 2. *Canthocalanus pauper* (Giesbrecht). (a) Male, lateral view. (b) Male urosome. (c) Male, left 5th leg, in flexed position, (d) Male, 5th pair of legs, posterior view. (2.b&d Dakin and Colefax, 1940; Kasturirangan, 1963).

Family **CENTROPAGIDAE** Giesbrecht, 1893

Genus ***Centropages***

The endopodites of the 5th legs are 3-segmented and with plumose setae, constructed as swimming legs; the 2-segmented appearance of the endopods of legs 1 to 4 is secondary owing to the fusion of the proximal segment with the middle segment, partially in leg 4 and more completely in legs 3, 2 and 1.

1. *Centropages furcatus* (Dana) **Female**: Posterior margin of metasome provided with two smaller, more dorsally placed spines in addition to the two large ones; a tooth present on the anterior margin of segments 1, 2 and 5 of 1st antennae; eye, red in colour, in continuous movement in the living condition. Length of female 1.9 mm; (Fig.1. a & b).

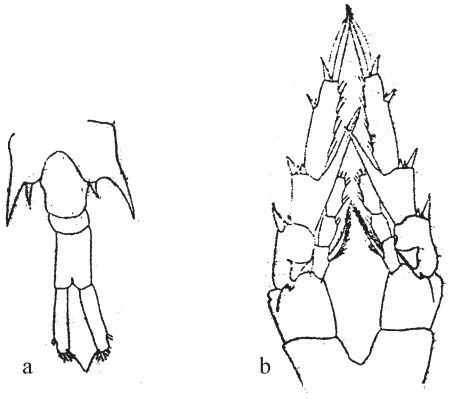

Fig. 1. *Centropages furcatus* (Dana). (a) Female urosome and part of metasome dorsal view. (b) Female, 5th pair of legs, posterior view. (Dakin and Colefax, 1940).

Male: Same as in female. Length of male 1.5 to 1.7 mm; (Fig. 2. a, b & c).

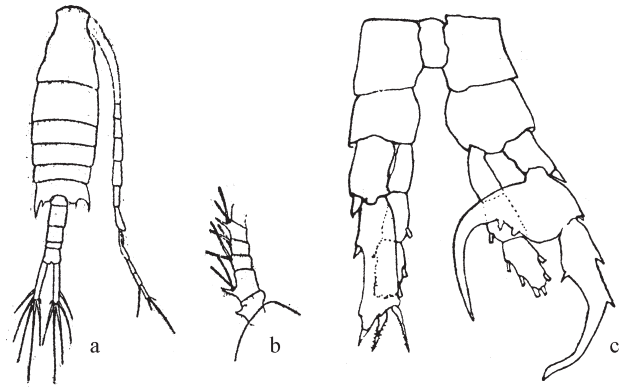

Fig. 2. *Centropages furcatus* (Dana). (a) Male dorsal view. (b) Male proximal five segments of 1st Antenna. (c) Male 5th pair of legs, posterior view. (2.a&b Dakin and Colefax, 1940; Kasturirangan, 1963).

2. ***Centropages orsinii*** Giesbrecht **Female**: Urosome 3-segmented; length 1.7 mm; (Fig. 1. a & b).

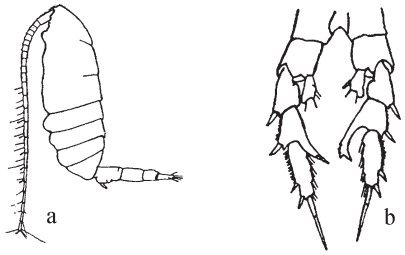

Fig. 1. *Centropages orsinii* Giesbrecht. (a) Female, lateral view. (b) Female, 5th pair of legs, posterior view. (Kasturirangan, 1963).

Male: Urosome 4-segmented; length 1.3 to 1.5 mm; (Fig. 2. a & b).

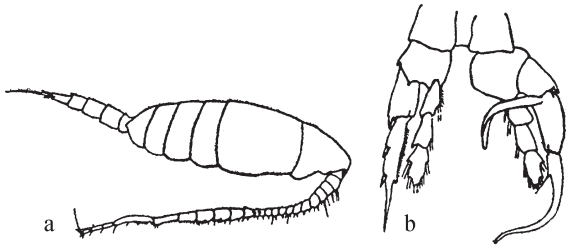

Fig. 2. *Centropages orsinii* Giesbrecht. (a) Male, lateral view. (b) Male, 5th pair of legs, posterior face. (Kasturirangan, 1963).

Family **DIAPTOMIDAE** Baird, 1850

Exclusively a freshwater family consisting of about 30 genera in two subfamilies, many are common and widely distributed in the tropical waters. Most of the genera belong to the subfamily Diaptominae.

Genus ***Diaptomus***

1. Diaptomus species. **Female**: Body slender, endopod 3-segmented in the 2nd, 3rd and 4th thoracic legs except the 1st which is 2-segmented; 5th leg biramous, rami 1 to 2-segmented with or without two apical setae; (Fig. 1. a).

Male: 5th legs asymmetrical, endopod rudimentary, right leg ending in a single claw; furcal processes short; (Fig. 2. a).

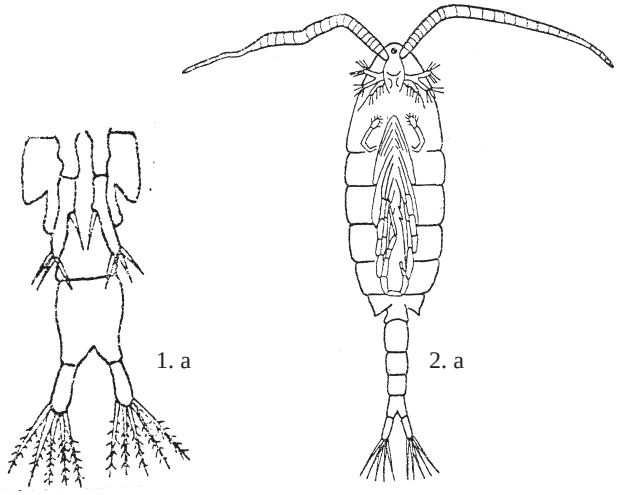

Fig. 1 a. *Diaptomus* sp. Female urosome and part of metasome. 2 a. *Diaptomus* sp. Male ventral view. (Sehgal, 1983).

Family **PARACALANIDAE** Giesbrecht, 1893

Genus ***Paracalanus***

Terminal segment of the exopodites of legs 2, 3 and 4 is separated into a proximal and a distal portion by the outer marginal spine such that the proximal portion is at least twice as long as the distal portion; 2nd antenna of the female with the 7-segmented exopodite as long as the 2-segmented endopodite; 5th legs present in female.

1. *Paracalanus parvus* (Claus) **Female**: First antennae not generally reaching beyond the caudal rami, surface of basipod 1 of legs 1 to 4 beset by hairs and bristles; urosome 4-segmented; 5th legs symmetrical, 2-segmented, genital opening oval, broader than long. Length 0.8 to 1.00 mm; (Fig.1. a, b, c & d).

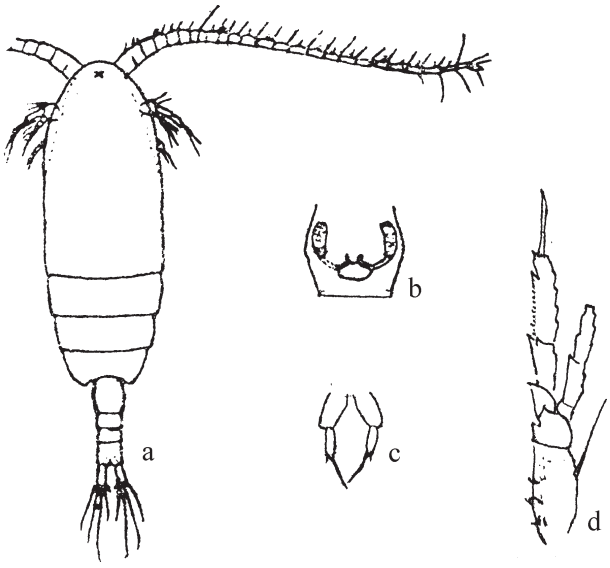

Fig. 1. *Paracalanus parvus* (Claus) (a) Female dorsal view. (b) Female genital segment, ventral view. (c) Female 5th pair of legs. (d) Female 4th leg, to show hairs and spines on the 1st basipodite segment. (Kasturirangan, 1963).

Male: First antennae not generally reaching beyond the caudal rami, surface of basipod 1 of legs 1 to 4 beset by hairs and bristles; urosome 5-segmented; 5th legs asymmetrical, 2-segmented on the right and 5-segmented on the left, left foot much longer; bubble like eminence on cephalosome indistinct or absent in profile view. Length 0.9 to 1.00 mm; (Fig.2. a, b & c).

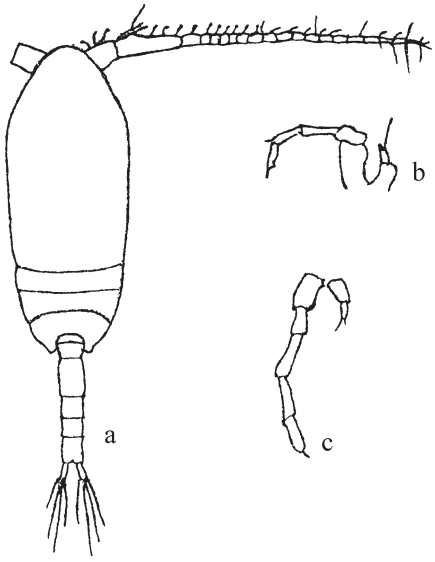

Fig. 2. *Paracalanus parvus* (Claus) (a) Male dorsal view. (b & c) Male 5th pair of legs two views. (Kasturirangan, 1963).

2. Paracalanus aculeatus (Giesbrecht) **Female**: First antennae reaching beyond the caudal rami; surface of basipod 1 of legs 1 to 4 naked except for one plumose seta though hairs and bristles occur on the segments of the exopod and endopod. Urosome 4-segmented; 5th legs symmetrical, 2-segmented, genital opening circular. Length 1.25 mm; (Fig.1. a, b & c).

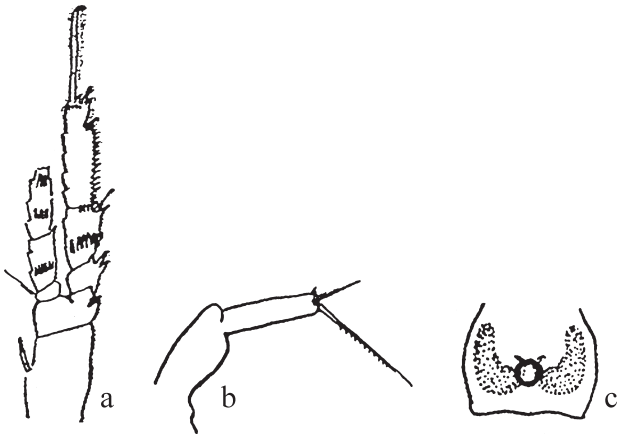

Fig. 1. *Paracalanus aculeatus Giesbrecht*, (a) Female 4th leg, to show absence of hairs and spines on the 1st basipodite segment. (b) Female 5th leg. (c) Female genital segment, ventral view. (Kasturirangan, 1963).

Male: First antennae reaching beyond the caudal rami; surface of basipod 1 of legs 1 to 4 naked except for one plumose seta though hairs and bristles occur on the segments of the exopod and endopod urosome 5-segmented; 5th legs asymmetrical, short and 3-segmented on the right side, long and 5-segmented on the left side, bubble like eminence on cephalosome quite distinct in profile view. Length 1.20 mm; (Fig.2. a & b).

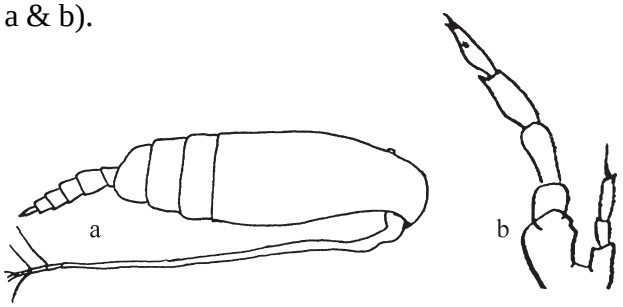

Fig. 2. *Paracalanus aculeatus* Giesbrecht (a) Male lateral view. (b) Male, 5th pair of legs. (Kasturirangan, 1963).

Genus ***Acrocalanus***

Terminal segment of the exopodites of legs 2, 3 and 4 is separated into a proximal and a distal portion by the outer marginal spine such that the proximal portion is less than twice as long as the distal portion; 2nd antenna of the female with the 7-segmented exopodite shorter than the 2-segmented endopodite; 5th legs absent in female.

1. ***Acrocalanus gibber*** Giesbrecht **Female**: First antenna does not reach beyond caudal rami; cephalosome in lateral view with a humped outline; body compact, urosome 4 - segmented; 5th legs absent. Length 0.93 to 1.00 mm; (Fig.1. a & b).

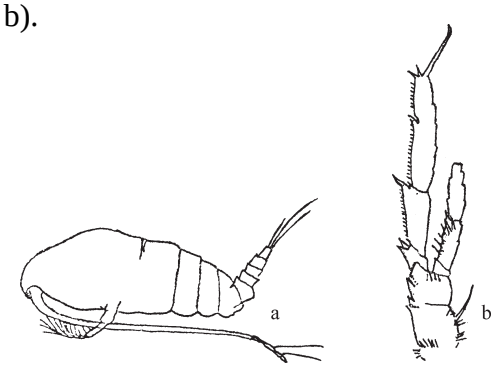

Fig. 1. *Acrocalanus gibber* Giesbrecht (a) Female lateral view. (b) Female 4th leg. (Kasturirangan, 1963).

Male: Urosome 5-segmented; 5th leg 4-segmented present on the left side only.

2. ***Acrocalanus longicornis*** Giesbrecht **Female**: First antenna reaches beyond caudal rami; cephalosome in lateral view not humped outline; body more elongated, urosome 4 - segmented; 5th legs absent. Length 1.14 to 1.20 mm; (Fig.1. a & b).

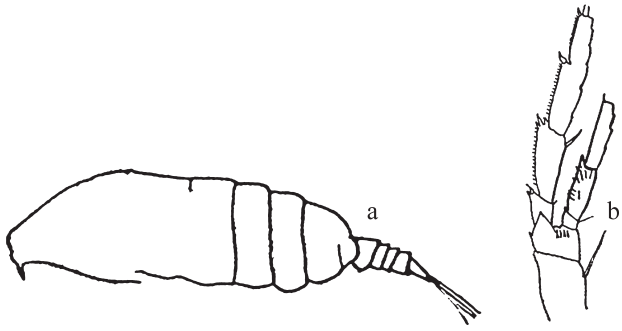

Fig. 1. *Acrocalanus longicornis* Giesbrecht (a) Female lateral view. (b) Female 4th leg. (Kasturirangan, 1963).

Male: Urosome 5-segmented; 5th leg 4-segmented present on the left side only.

Family **PONTELLIDAE** Dana, 1852

Genus ***Labidocera***

Body not usually pellucid, anterior lip not greatly enlarged; 5th legs not very slender or spine like; endopod of 2nd antenna 2-segmented with distal segment shorter than proximal. One pair of cuticular eye-lenses present dorsally on the cephalosome**.** Females only: urosome 3-segmented; 1st antennae symmetrical. Males only: urosome 5-segmented, 1st antenna geniculate on the right side.

1. ***Labidocera minuta*** Giesbrecht **Female**: Posterior margins of metasome rounded, with a very small projection present only on the right side, not visible in dorsal view; length 2.1 mm; (Fig. 1.a, b, c & d).

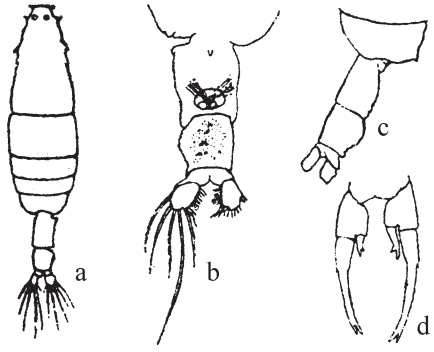

Fig. 1. *Labidocera minuta* Giesbrecht (a) Female dorsal view. (b) Female part of metasome and urosome ventral view. (c) Female part of metasome and urosome dorosolateral view. (d) Female 5th pair of legs. (Kasturirangan, 1963).

Male: Corners of metasome drawn out into prominent spines, the spine on the right side longer and somewhat spatulate; length 1.54 to 1.75 mm; (Fig. 2.a & b).

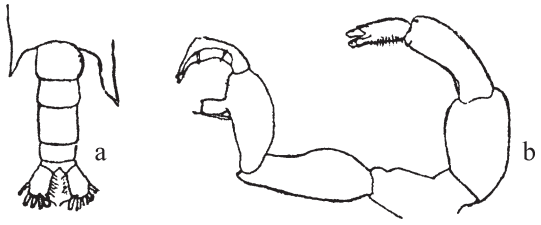

Fig. 1. *Labidocera minuta* Giesbrecht (a) Male part of metasome and urosome dorsal view. (b) Male 5th pair of legs. (Kasturirangan, 1963)

3. Labidocera pectinata Thompson & Scott **Female**: Corners of metasome drawn out into curved points that can be clearly seen in lateral view, length 2.1 mm; (Fig.1. a, b, c & d) and (Fig.1.2. a, b & c).

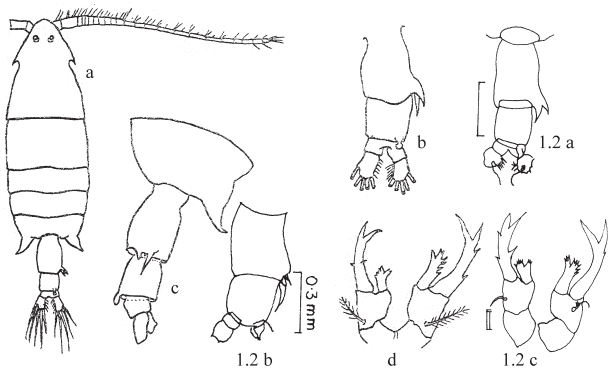

Fig. 1. *Labidocera pectinata* Thompson and Scott (a) Female dorsal view. (b) Female urosome dorsal view. (c) Female part of metasome and urosome view from the right. (d) Female 5th pair of legs, posterior view.

Fig. 1.2. *Labidocera pectinata* Thompson and Scott (a) Female urosome. (b) Urosome female (variant). (c) Female 5th pair of legs. (1.2a, 1,2b, 1.2c Silas and Pillai, 1973; Kasturirangan, 1963).

Male: Corners of metasome drawn out into prominent spines, the spine on the right side bifid, length 1.7 mm; (Fig.2. a, b & c) and (Fig. 2.1. a, b & c).

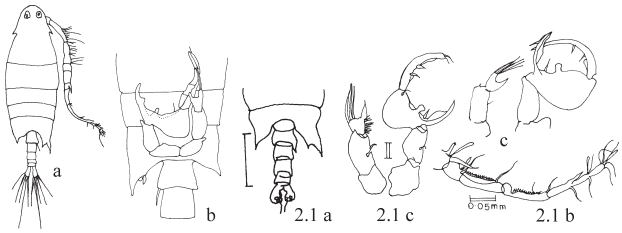

Fig. 2. *Labidocera pectinata* Thompson and Scott (a) Male dorsal view. (b) Male ventral view to show 5th pair of legs in position. (c) Male 5th pair of legs.

Fig. 2.1. *Labidocera pectinata* Thompson and Scott (a) Male urosome dorsal view. (b) Male 1st antenna. (c) Male 5th pair of legs. (2.1a, 2.1b, 2.1c Silas and Pillai, 1973; Kasturirangan, 1963).

3. ***Labidocera pavo*** Giesbrecht **Female**: Corners of metasome end in points but not drawn out; urosome condensed, very short, with a peg-like projection on the right side, length 1.9 mm; (Fig. 1. a, b, c & d).

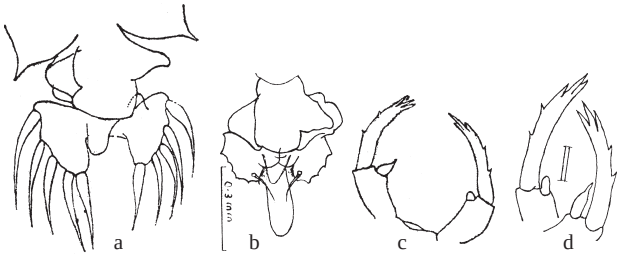

Fig. 1. *Labidocera pavo* Giesbrecht (a) Female dorsal view of metasome corners and urosome. (b) Female urosome dorsal view. (c) Female 5th pair of legs. (d) Female 5th pair of legs. (1.b, 1.d Silas and Pillai, 1973; Kasturirangan, 1963).

Male: Posterior margins of metasome end in points not drawn out. Right 5th leg chelate with a well-developed thumb, claw elongate, curved and with a blunt conical projection. Left leg with one outer marginal spine and three terminal subequal spines on the terminal segment, a distolateral spine on the subterminal segment, length 1.9 mm; (Fig. 2. a & b) and (Fig.2.1. c, d & e).

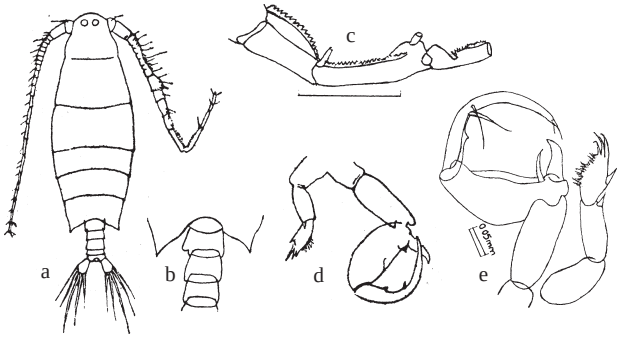

Fig. 2. *Labidocera pavo* Giesbrecht (a) Male dorsal view. (b) Male urosome dorsal view. (c) Male 1st antenna. (d) Male 5th pair of legs. (e) Male 5th pair of legs. (2.b, 2.c, 2.e, Silas and Pillai, 1973; Kasturirangan, 1963).

Genus ***Pontella***

Cephalosome with lateral hooks, usually without a crest, one pair of dorsal cuticular eye lenses and ventral eye lens present; rostrum bifurcate with short rami and with distinct lens, which are well developed in male than in female. 5th pair of legs biramous in female, reduced or sometimes asymmetrical; uniramous in male, right leg chelate with stout finger and thumb.

1. ***Pontella danae*** Giesbrecht, var. ***ceylonica***, Thompson & Scott **Female**: Urosome 2-segmented, genital segment with various outgrowths and concealing the urosome segments in dorsal view; 1st antennae alike on the two sides. Corners of metasome slightly asymmetrical, the left one a little longer; right caudal ramus distinctly larger and bearing a vertical crest-like extension visible in lateral view; left 5th leg distinctly longer with 2 outer spines on exopodite one of which is very clear; length 3.4 mm; (Fig.1. a, b, c & d) and (Fig. 1.2. a, b & c).

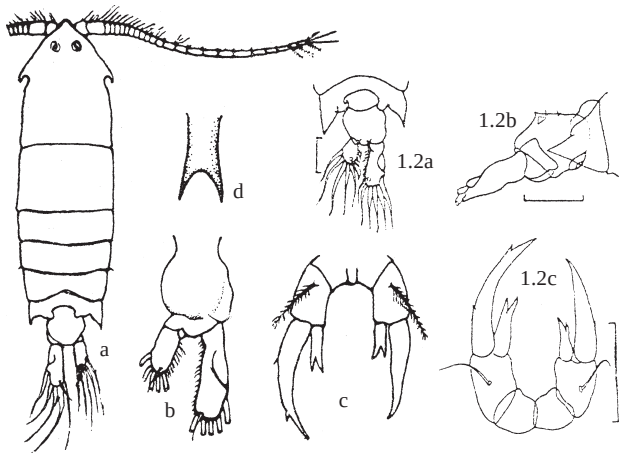

Fig. 1. *Pontella danae* Giesbrecht (a) Female dorsal view, *variety ceylonica.* (b) Female urosome dorsal view, *variety ceylonica.* (c) Female 5th pair of legs, *variety ceylonica.* (d) Female rostrum, *variety ceylonica.*
Fig. 1.2. *Pontella danae ceylonica.* (a) Female urosome dorsal view. (b) Female urosome lateral view. (c) Female 5th pair of legs. (1.2a, 1.2b, 1.2c Silas and Pillai, 1973; Kasturirangan, 1963).

Male: Body robust; dorsal eye lenses, ventral lens and rostral lens well developed; antennae geniculate; segment 14 with a long dorsal spine carrying a small flagellum at tip; segment 18 with dorsal toothed plate. Urosome 5-segmented, right 5th leg chelate; hand of chela with a well developed conical thumb; inner margin of hand provided with a squared process towards base of thumb; externally another conical spine present turned inwards; finger with a crescentic outgrowth at its inner mid-margin and terminates in a small hook which carry a seta; left 5th leg: terminal segment with 2 outer marginal spines and 2 distal spines, outer distal spine curved with serrated margin; inner margin of segment with setose hairs; subterminal segment with a disto-lateral spine. Length 3.1 mm; (Fig. 2. a & b) and (Fig. 2.1. a, b, c & d).

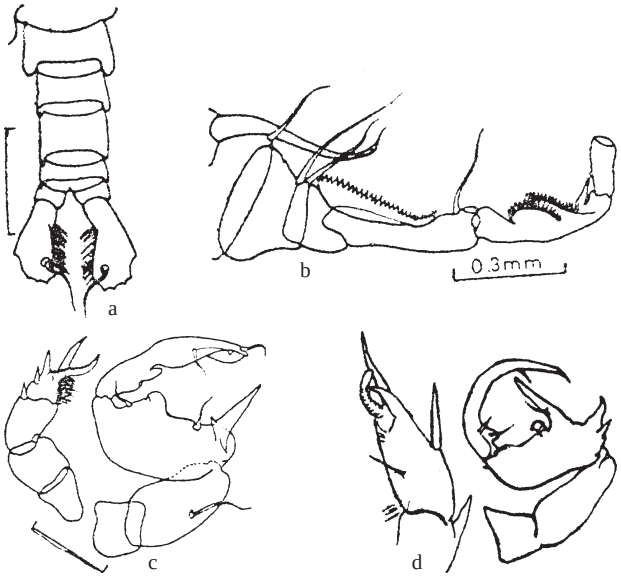

Fig. 2. *Pontella danae* Giesbrecht (a) Male urosome dorsal view. (b) Male 1st antenna. (c) Male 5th pair of legs. (d) Male 5th pair of legs. (2.a, 2.b, 2.c Silas and Pillai, 1973; Kasturirangan, 1963).

2. *Pontella investigatoris* Sewell, **Female**: Body robust; lateral cephalic hooks absent; dorsal eye lenses developed; rostrum bifurcate; urosome 2-segmented, genital segment with a conical lobe and rounded tip on its right side; posterior margin produced ventrally into a lobe extending to the middle of caudal rami; caudal setae short and bulbous at base; 1st antennae 23 segments; 5th legs asymmetrical; exopod with two outer marginal spines and terminates in three subequal spines, median spine longest; endopod asymmetrical, on left leg rounded and on right leg long and produced at its tip.

Male: Body robust; well-developed dorsal eye lenses, ventral lenses and rostral lenses; urosome 5-segmented; caudal rami asymmetrical, right ramus stout. Right antenna geniculate; segments 18 and fusion segments 19-21 carrying sharp denticulate plates on their dorsal margins; segment 14 with a long spine and a small flagellum at its tip;2 toothed plates on segments 19-21; 5th right leg chelate: thumb is a well developed, curved stout spine; inner margin of hand with a quadrate process, dorsal margin with a seta at its base; claw curved, elongated with 3 inner marginal and 1 outer distal spine; left leg: terminal segment short with 1 outer marginal spine, 2 terminal spines and a flagelliform process; inner margin of segment provided with 2 patches of hairs; subterminal segment with a distolateral spine; (Fig.1. a, b & c).

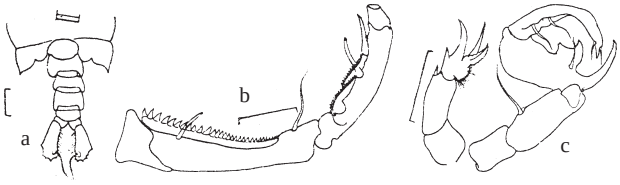

Fig. 1. *Pontella investigatoris* Sewell (a) Male urosome dorsal view. (b) Male 1st antenna. (c) Male 5th pair of legs. (Silas and Pillai, 1973)

Family **PSEUDODIAPTOMIDAE** Sars, 1902

Genus ***Pseudodiaptomus***

5th legs uniramous in female and usually in male also, rarely with only indistinct indications of the endopod in male. 1st antennae in female 20-22 segments.

1. *Pseudodiaptomus annandalei* Sewell **Female**: Urosome 4-segemented, 1st antennae alike on two sides. Genital segment with a prominent spine on each side pointing outwards; length 1.18 mm; (Fig.1. a, b, c, d & e).

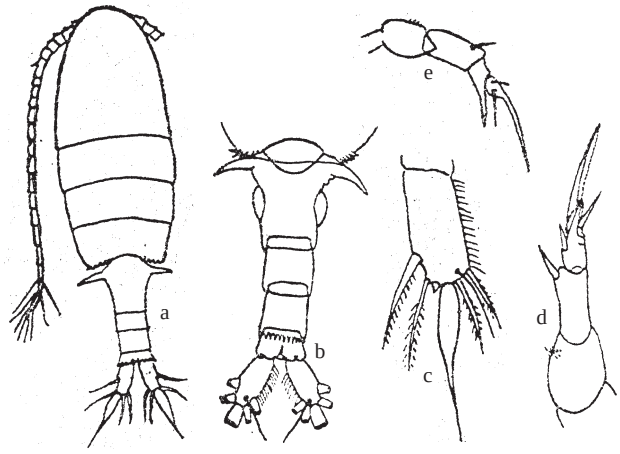

Fig. 1. *Pseudodiaptomus annandalei* Sewell (a) Female dorsal view. (b) Female urosome and part of metasome dorsal view. (c) Female caudal ramus and setae. (d) Female 5th leg of one side. (e) Female 5th leg. (1.b, 1.d Pillai, 1976; Kasturirangan, 1963).

Male: Urosome, 5-segmented, 1st antennae geniculate on the right side. 5th legs uniramous, length 1.09 mm; (Fig. 2. a & b).

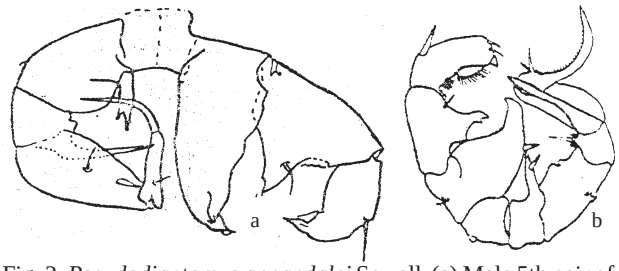

Fig. 2. *Pseudodiaptomus annandalei* Sewell (a) Male 5th pair of legs anterior view. (b) Male 5th pair of legs dorsal view. (2.b Pillai, 1976; Kasturirangan, 1963).

2. *Pseudodiaptomus serricaudatus* (T. Scott) **Female**: Genital segment without laterally pointing spines, slightly asymmetrical, the posterior margin produced more backwards on the right than on the left; all urosome segments with a regular row of triangular teeth on posterior margin, length 0.9 to 1.2mm; (Fig. 1. a, b, c, d, e, f & g).

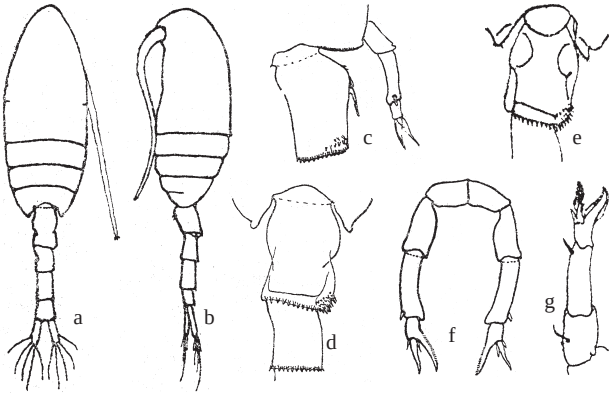

Fig. 1. *Pseudodiaptomus serricaudatus* (T. Scott) (a) Female dorsal view. (b) Female lateral view. (c) Female dorso-lateral view of last metasome and genital segments; 5th leg of right side is shown. (d) Female Dorsal view of genital and succeeding segments with triangular teet on posterior margin. (e) Female urosome lateral view. (f) Female 5th pair of legs. (g) Female 5th leg. (1.e, 1.g Pillai, 1976; Kasturirangan, 1963).

Male: 5th legs are highly complex as figured, left leg bear a long blade-like endopod, length 0.9-1.1 mm; (Fig. 2. a & b).

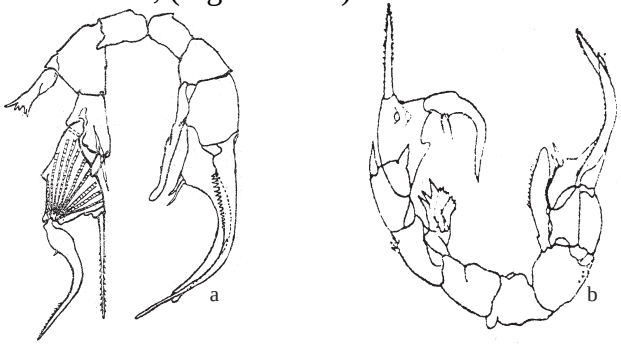

Fig. 2. *Pseudodiaptomus serricaudatus* (T. Scott) (a) Male 5th pair of legs anterior view. (b) Male 5th pair of legs dorsal view. (2.b Pillai, 1976; Kasturirangan, 1963).

Family **TEMORIDAE** Giesbrecht, 1893

Genus ***Temora***

Body short, compact, and head-end massive, caudal rami over six times as long as broad.

1. *Temora turbinata* (Dana) **Female**: Urosome 3-segmented, 5th legs 3-segmented and symmetrical. Posterior margin of metasome rounded; length 1.50 mm; (Fig. 1.a & b).

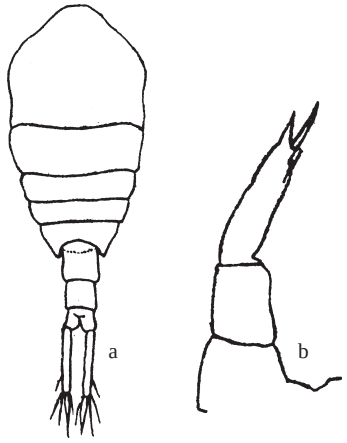

Fig. 1. *Temora turbinata* (Dana) (a) Female dorsal view. (b) Female 5th leg. (Kasturirangan, 1963).

Male: Urosome 5-segmented, 5th legs 3-segmented and asymmetrical, the left leg forms a chela. Posterior margin of metasome rounded, length 1.40 mm; (Fig. 2.a & b).

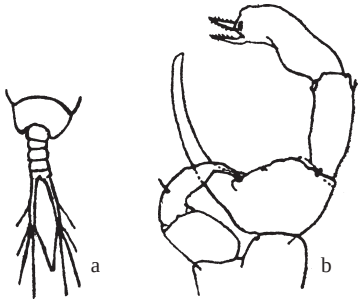

Fig. 2. *Temora turbinata* (Dana) (a) Male urosome dorsal view. (b) Male 5th pair of legs. (2.a Dakin and Colefax, 1940; Kasturirangan, 1963).

Order **CYCLOPOIDA** Burmeister, 1834

Family **CYCLOPIDAE** Dana, 1846

Subfamily **CYCLOPINAE** Sars, 1914

Genus ***Mesocyclops***

Body slender and clearly demarcated into anterior and posterior parts. Receptaculum seminis malleiform. Caudal rami relatively short ranging between 2.5-3.5 times as long as wide. 5th leg 2-segmented, distal segment with long seta and short spine (Fig. 1. a, b & c).

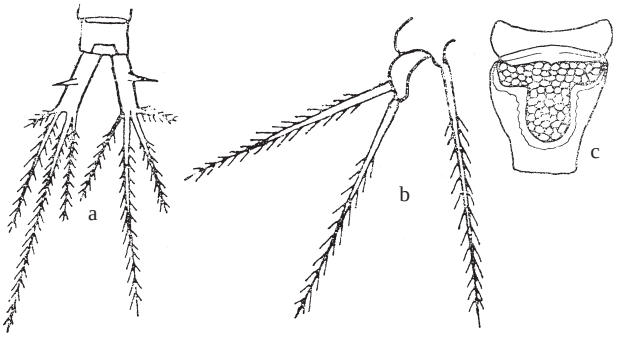

Fig. 1. *Mesocyclops* sp (a) Female caudal furca and furcal setae. (b) Female 5th leg. (c) Female receptaculum seminis. (Seghal, 1983).

1. Mesocyclops (Mesocyclops) leuckarti Claus **Female**: Antennae 17-segmented and reaching to the posterior end of second thoracic segment, spine formula 3,4,4,3. Abdominal segments 4; receptaculum seminis large with a wide posterior sac. Caudal rami 2.9-3.2 times as long as wide; furcal setae 5. Each ramus inner apical seta more than twice the length of outer one; median apical seta long and well developed. 5th leg large, inner setiform spine on distal segment slightly shorter than apical seta. Average body length 0.87-1.21 mm; (Fig. 1.a, b, c, d & e).

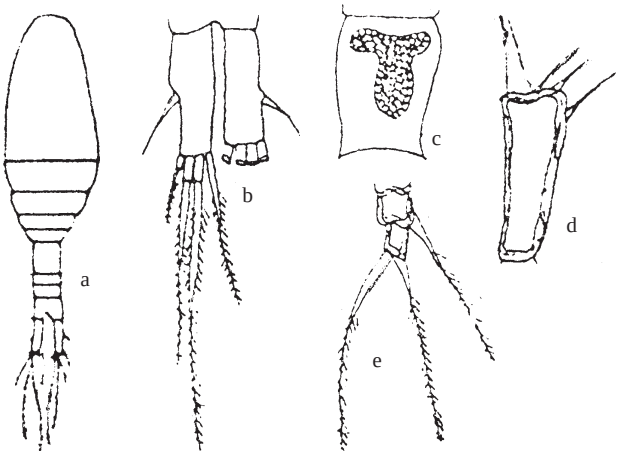

Fig. 1. *Mesocyclops (Mesocyclops) leuckarti* Claus (a) Female dorsal view. (b) Female caudal furca and setae. (c) Female receptaculum seminis. (d) Female distal segment of 1st antenna. (e) Female 5th leg. (Seghal, 1983).

Male: Antennae 16-segmented. Abdominal segments 4; 5th leg with short inner spine and two long setae; inner spine inserted in the middle of distal segment. Length 0.82-0.89 mm; (Fig. 2. a).

Fig. 2. *Mesocyclops (Mesocyclops) leuckarti* Claus (a) Male 5th leg. (Seghal, 1983).

Family **OITHONIDAE** Dana, 1852

Genus ***Oithona***

Cuticular eye-lenses not present on the cephalosome. Body not depressed cyclopoid form. Genital segment only on a little larger than the other urosome segments, maxillipeds and 2nd maxillae slender, covered with numerous spiny bristles. **Females**: Metasome very slender, fusiform; head terminating in front in a pointed rostrum; urosome 5-segmented; genital segment a little wider than the other urosome segments. **Males**: Metasome not so slender, smaller in length; head-end truncate, without rostrum; each 1st antennae twice geniculate with fewer setae than in females; urosome 6-segmented, genital segment wider than the other urosome segments.

1. *Oithona rigida* Giesbrecht **Female**: Rostrum bent down, not visible in dorsal view; body length less than 1 mm; Antennae reach up to the end of 3rd metasome segment only; outer marginal

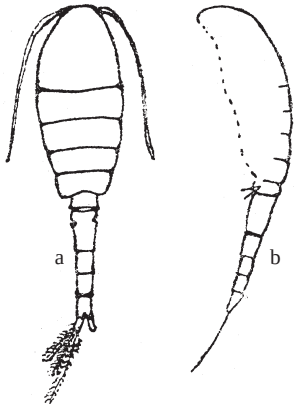

Fig. 1. *Oithona rigida* Giesbrecht (a) Female dorsal view. (b) Female lateral view. (Kasturirangan, 1963)

spines are 3, 3, 3, 2 in terminal exopod segments of legs 1 to 4; body much pigmented usually; apical setae of caudal rami not greatly elongated but coarsely plumose forming a fan; length 0.75 to 0.85 mm; (Fig. 1.a & b).

Male: Antennae twice geniculate; sheathing base appears to be present semicircular process is absent. Outer marginal spines are 3, 3, 3, 2 in terminal exopod segments of legs 1 to 4; length 0.7 mm; ***Oithona rigida*** is the commonest species of *Oithona* in inshore waters.

2. *Oithona brevicornis* Giesbrecht **Female**: Antennae reach up to 2nd metasome segment only; outer marginal spines are 3, 3, 3, 2 in terminal exopod segments of legs 1 to 4; the two longer setae on each caudal ramus show a peculiar crossed arrangement; length 0.6 mm; (Fig. 1. a).

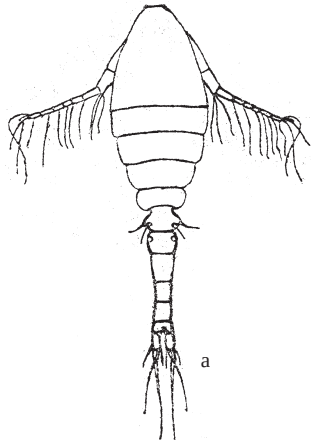

Fig. 1. *Oithona brevicornis* Giesbrecht (a) Female dorsal view. (Kasturirangan, 1963).

Male: Antennae twice geniculate; neither proximal sheath nor distal semicircular process is present; outer marginal spines are 3, 3, 3, 2 in terminal exopod segments of legs 1 to 4; length 0.55 mm.

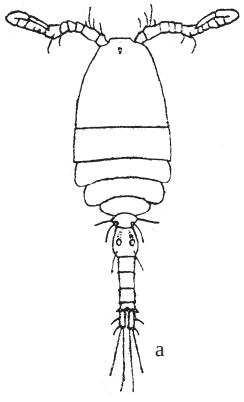

Fig. 2. *Oithona brevicornis* Giesbrecht (a) Male dorsal view. (Kasturirangan, 1963).

Order **HARPACTICOIDA** Sars, 1903

Family **CLYTEMNESTRIDAE** Scott, 1909

Genus ***Clytemnestra***

Body depressed, with angular projection at the posterior corners of the cephalosome and the next three segments, 5th legs long, narrow, 2-segmented, tipped with setae and without the characteristic inward expansion of the basal segment in Harpacticoida.

1. Clytemnestra scutellata Dana **Female**: Exopod of 2nd antenna represented by two long setae; 1st antenna 8-segmented; caudal rami twice as long as broad; apical caudal setae quite short in females; length 1.07 to 1.30 mm; (Fig. 1. a, b, c, d, e & f).

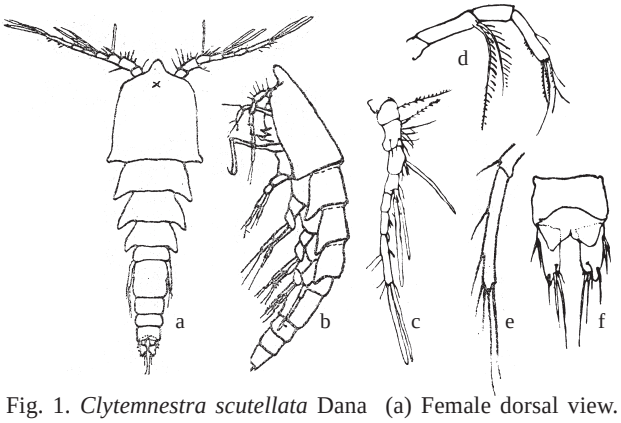

Fig. 1. *Clytemnestra scutellata* Dana (a) Female dorsal view. (b) Female lateral view. (c) Female 1st antenna. (d) Female 2nd antenna. (e) Female 5th leg. (f) Female caudal rami and anal segment. (Kasturirangan, 1963).

Male: Apical caudal setae very long in males, caudal rami twice as long as broad, length 1.07 – 1.30 mm; (Fig. 2. a).

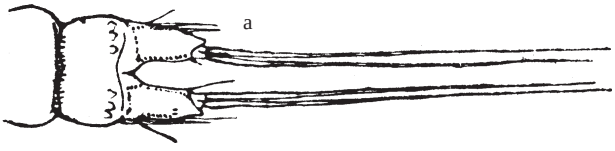

Fig. 2. *Clytemnestra scutellata* Dana (a) Male last two segments of urosome and caudal rami. (Kasturirangan, 1963)

Family **ECTINOSOMATIDAE** Sars, 1903

Genus ***Microsetella***

Endopods of 2nd legs not elongated; body fusiform; caudal setae very long.

1. *Microsetella norvegica* (Boeck) **Female**: Caudal rami as long as broad, inconspicuous, 2nd antennae with 3-segmented exopodite, small in size, less than 0.85mm. The inward expansion of the basal of the 5th leg bears one short and one long seta; caudal setae about as long as the body; length of female 0.35 to 0.53mm; (Fig. 1. a, b, c & d).

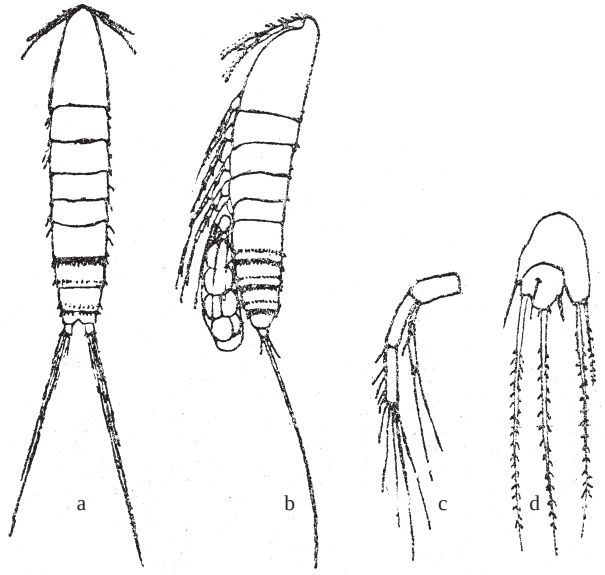

Fig. 1. *Microsetella norvegica* (Boeck) (a) Female dorsal view. (b) Female lateral view. (c) Female 2nd antenna. (d) Female 5th leg. (Kasturirangan, 1963).

Male: Second antennae with 3-segmented exopodite, length of male 0.33 to 0.42 mm; (Fig. 2.a).

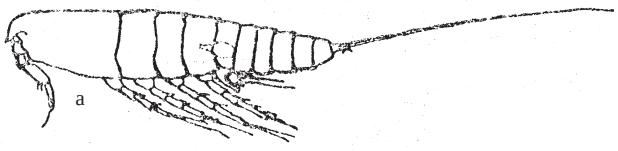

Fig. 1. *Microsetella norvegica* (Boeck) (a) Male lateral view. (Kasturirangan, 1963).

Family **EUTERPINIDAE** Brian, 1921

Genus ***Euterpina***

Body not depressed, 5th legs plate-like; without the characteristic inward expansion of the basal segment in Harpacticoida.

1. *Euterpina acutifrons* (Dana): **Female**: Body subpyriform; cephalosome drawn out in front into a greatly prominent rostral projection, acute at the tip; 5th legs formed by two undivided juxtaposed plates in the female, length of female 0.5 to 0.8 mm; (Fig. 1.a, b, c & d).

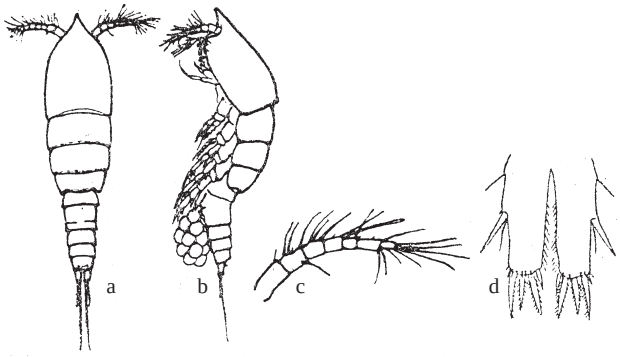

Fig. 1. *Euterpina acutifrons* (Dana) (a) Female dorsal view. (b) Female lateral view. (c) Female 1st antenna. (d) Female 5th pair of legs. (1.d Dakin and Colefax, 1940; Kasturirangan, 1963).

Male: 5th legs formed by two undivided juxtaposed plates coalesced in the middle in male; length of male 0.5 to 0.66 mm; (Fig. 2.a, b & c).

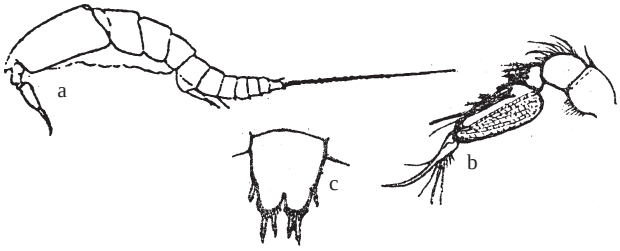

Fig. 2. *Euterpina acutifrons* (Dana) (a) Male lateral view. (b) Male 1st antenna. (c) Male 5th pair of legs. (2.a Dakin and Colefax, 1940; Kasturirangan, 1963).

Family **LONGIPEDIIDAE** Sars, 1903

Genus ***Longipedia***

5th pair of legs with the basal segment possessing the inward expansion characteristic of the Harpacticoida. Endopods of 2nd legs greatly elongated; inward expansion of 5th legs narrow, curved and pointed.

1. *Longipedia weberi* A. Scott **Female**: Anal operculum with the central tooth a little longer than the two teeth on each side length 0.95 mm; (Fig.1. a, b, c, d & e).

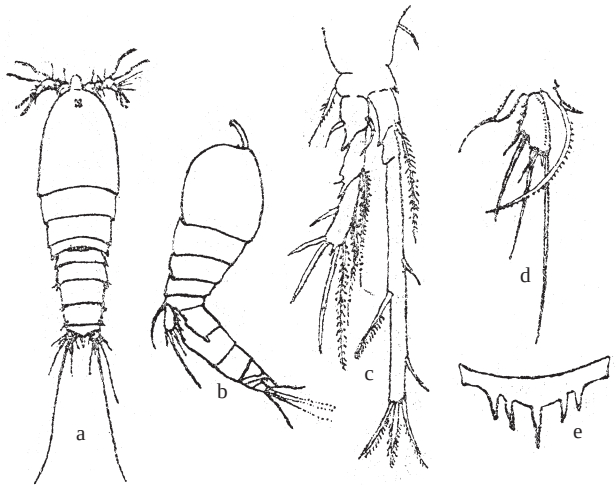

Fig. 2. *Longipedia weberi* A. Scott (a) Female dorsal view. (b) Female lateral view. (c) Female 2nd leg. (d) Female 5th leg. (e) Female anal operculum. (Kasturirangan, 1963)

Family **MACROSETELLIDAE**

Genus ***Macrosetella***

Endopods of 2nd legs not elongated; body fusiform; caudal setae very long.

1. Macrosetella gracilis (Dana) **Female**: Caudal rami slender, cylindrical, over 4 times as long as broad; 2nd antennae without any exopodite; larger in size, over 1.0 mm; caudal setae about as long as the body; length 1.4 to 1.5 mm., (Fig.1.a & b).

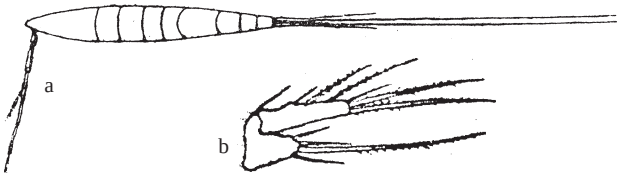

Fig. 1. *Macrosetella gracilis* (Dana) (a) Female dorsal view. (b) Female 5th leg. (1.b Dakin and Colefax, 1940; Kasturirangan, 1963).

Male: Length 1.16 to 1.30 mm; (Fig.2.a & b).

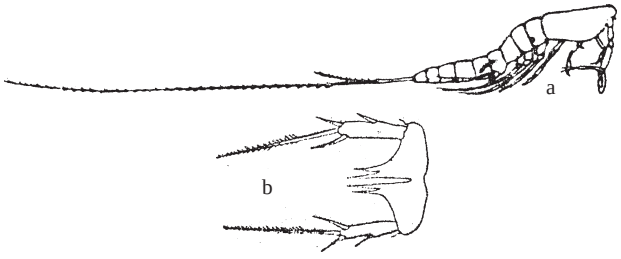

Fig. 2. *Macrosetella gracilis* (Dana) (a) Male lateral view. (b) Male 5th pair of legs. (2.b Dakin and Colefax, 1940; Kasturirangan, 1963).

Order **POECILOSTOMATOIDA** Thorell, 1859

Family **CORYCAEIDAE** Dana,1852

Genus ***Corycaeus***

Cuticular eye-lenses present on the cephalosome. Body not at all depressed; club-shaped; head round anteriorly, usually the last metasome segment and always the penultimate segment provided with tailward prolongations or 'lappets'; 2nd antennae stout and 3-segmented, subchelate, larger in the males than in the females, single egg-sac borne dorsally on the genital segment; caudal rami styliform. The two free metasome segments usually not fused together; urosome 2-segmented; no beak-shaped process on the ventral surface.

1. ***Corycaeus danae*** Giesbrecht **Female**: Lappets of metasome long, but not reaching up to the end of genital segment in the female; genital segment over hangs the anal segment in the female as seen in lateral view; length of female 1.6 -1.7 mm; (Fig. 1.a, b & c).

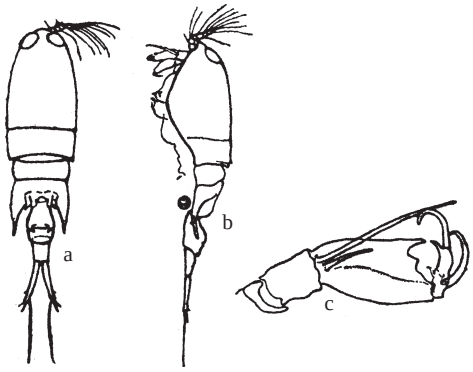

Fig. 1. *Corycaeus danae* Giesbrecht (a) Female dorsal view. (b) Female lateral view. (c) Female 2nd antenna. (Kasturirangan, 1963).

Male: Lappets of metasome long but not reaching up to the middle of the genital segment. Length of male 1.4- 1.5 mm; (Fig. 2. a & b)**.**

Fig. 1. *Corycaeus danae* Giesbrecht (a) Male dorsal view. (b) Male 2nd antenna. (Kasturirangan, 1963).

Family **ONCAEIDAE** Giesbrecht, 1893

Genus ***Oncaea***

Cuticular eye-lenses not present on the cephalosome. Body not depressed, of cyclopoid form; genital segment conspicuously enlarged, succeeding segement inconspicuous, maxillipeds three segmented, subchelate forming powerful grasping organs in both sexes.

1. *Oncaea venusta* Philippi **Female**: Second free metasome segment not raised into a hump; anterior part of the body obovate in the female; genital segments followed by 3 segments which are closely telescoped together; length of female 1.1 to 1.27mm; (Fig. 1. a).

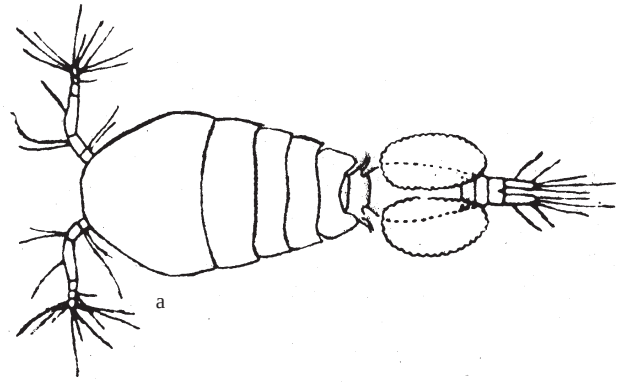

Fig. 1. *Oncaea venusta* Philippi (a) Female dorsal view. (Kasturirangan, 1963).

Male: Anterior part of the body less wide in the male; genital segment more conspicuously enlarged in the male than in the female and followed by 4 segments which are closely telescoped together; length 0.7 to 1.00 mm; (Fig. 2. a & b).

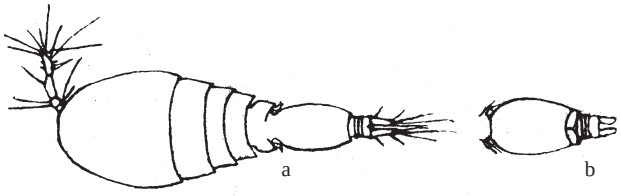

Fig. 2. *Oncaea venusta* Philippi (a) Male dorsal view. (b) Male urosome ventral view. (Kasturirangan, 1963).

Subclass **THECOSTRACA** Gruvel, 1905

Infraclass **CIRRIPEDIA** Burmeister, 1834

Superorder **THORACICA** Darwin, 1854

Order **SESSILIA** Lamarck, 1818

Suborder **BALANOMORPHA** Pilsbry, 1916

Superfamily **BALANOIDEA** Leach, 1817

Family **BALANIDAE** Leach, 1817

Scuta and terga articulated, freely movable and furnished with depressor muscles. Rostrum with radii, labrum notched in the middle. Third cirrus resembles the second cirrus. Illustrations on the external morphology, appendages and reproduction in barnacles are given in Fig. 1.a.

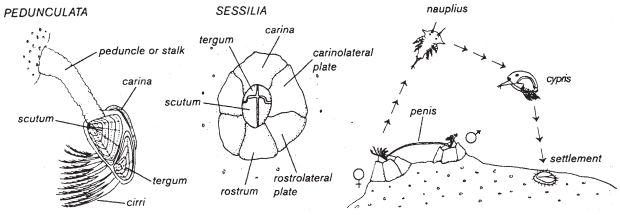

Fig. 1.a. External morphology, appendages and reproduction in barnacles. (Richmond, 1997).

Genus ***Balanus***

Shell cylindrical or conical. Composed of 6 compartments, opercular valves sub-triangular and as wide as orifice.

1. *Balanus amphitrite* var.***venustus*** Darwin: **Colour**: dirty white, with regular longitudinal violet-brown moderately broad stripes arranged in groups of 3 or 4, sheath dark brown, radii freckled in purple. Shell: conical, often depressed and laterally compressed in a few cases when attached to twigs. Basis calcareous with concentric ridges internally. Radii with crenated edges and septa denticulated on the lower side only. Scutum: articular ridge well developed. Tergum; angle of the apex very obtuse. Lower end of spur is square and nearly parallel with the basal margin. Labrum: Deep notched, teeth about

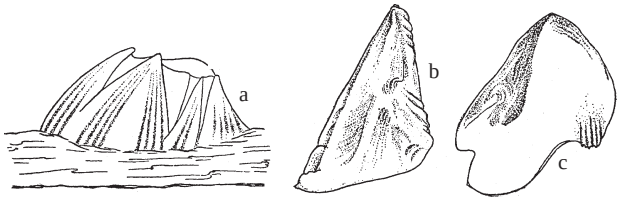

Fig. 1. (a) *Balanus amphitrite* var. *venustus*, Darwin attached to a twig. (b) Scutum internal view. (c) Tergum internal view of young. (Sundara Raj, 1927).

21; (Fig. 1.a, b, c, d, e, f, g & h). Very common, world wide in distribution. Largest is 16 mm along the basal diameter.

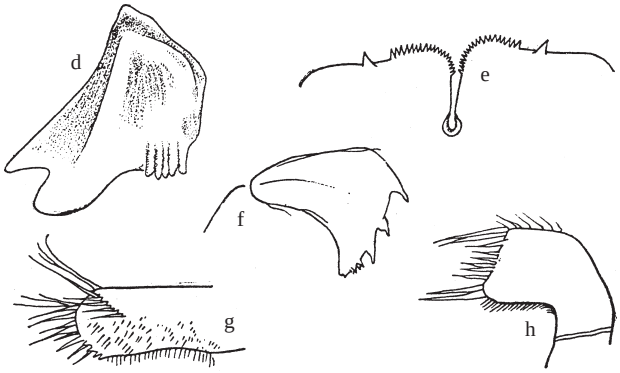

Fig. 1. *Balanus amphitrite* var. *venustus*, Darwin. (d) Tergum internal view of old animal. (e) Labrum. (f) Mandible. (g) Labial palp. (h) Maxilla. (Sundara Raj, 1927).

2. *Balanus tintinnabulum* (Linnaeus) var. ***communis*** Darwin: Radii transversely grooved throughout, walls stained inside with pale purple and the sheath with dark purple. Peripheral margin of the basis and the lower magin of the wall are ribbed inside. Growth ridges of the scutum are sometimes absent near the apex. Basis and radii penetrated by pores. Basal diameter is 65 mm; (Fig. 2.a, b, c, d & e). World wide in distribution.

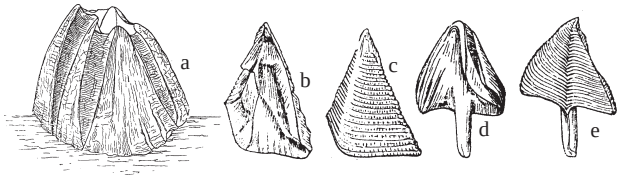

Fig. 2. (a) *Balanus tintinnabulum* (Linnaeus) var. *communis* Darwin. (b) Scutum internal view. (c) Scutum external view. (d) Tergum internal view. (e) Tergum external view. (Sundara Raj, 1927).

Superfamily **CORONULOIDEA** Leach, 1817

Family **CHELONIBIIDAE** Pilsbry, 1916

Genus ***Chelonia***

1. *Chelonia testudinaria* (Linnaeus): Characteristic turtle barnacle on the carapace of turtles seen lying on the island areas; (Fig. 1. a & b).

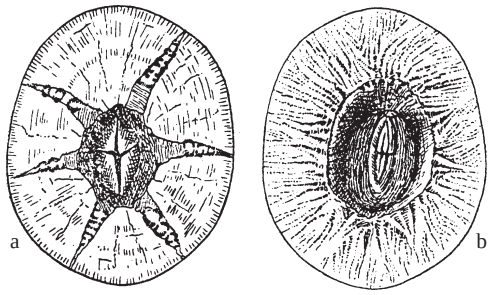

Fig. 1. (a) *Chelonia testudinaria* (Linnaeus) dorsal view. (b) ventral view. (Sundara Raj, 1927).

Order **PEDUNCULATA** Lamarck, 1818

Suborder **LEPADOMORPHA** Pilsbry, 1916

Family **LEPADIDAE** Darwin, 1852

Stalk and capitulum sharply marked off, peduncle flexible without calcareous plates. Scuta with an adductor muscle.

Genus ***Lepas***

Carina extending between the terga, ending below in a fork or disc. Scuta sub-triangular with their umbones at the rostral angle. Filaments beneath the basal articulation of the 1st cirri.

1. *Lepas anserifera* Linnaeus: Valves distinctly furrowed, especially the tergum. Right scutum has a well developed umbonal tooth; the left one has a small tooth, sometimes only a prominence. Occludent margin of the scuta arched and protuberant, 5 or 6 filaments on each side (Fig. 1. a & b).

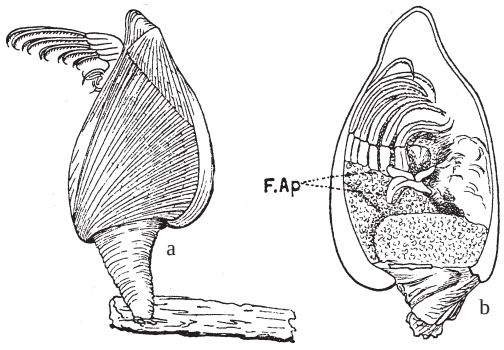

Fig. 1. (a) *Lepas anserifera* Linnaeus, dorsal view. (b) Internal view filamentary appendages. (Sundara Raj, 1927).

The nauplii and cypris stages of barnacles are often found in the plankton (Fig. 1. a, b, c, d & e).

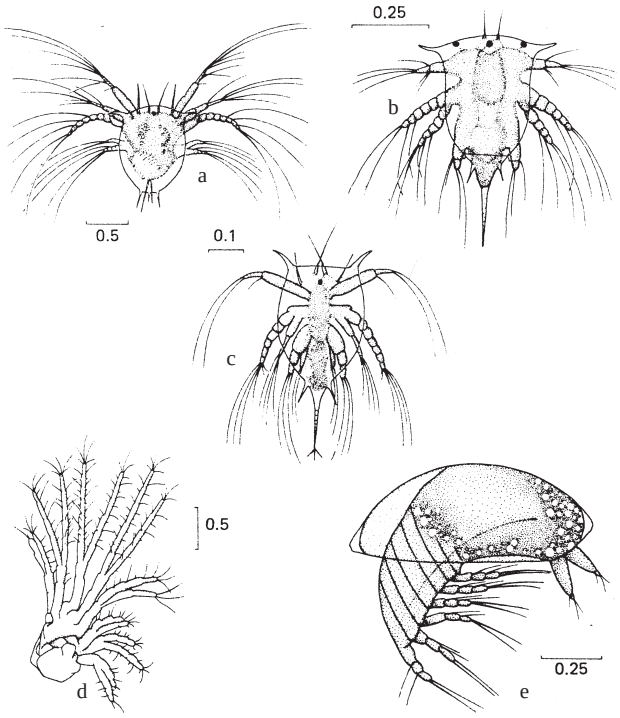

Fig. 1. Nauplii of barnacles (a, b & c). (d) Exoskeleton from molt of branacle. (e) Cypris larva of branacles. (Smith De Boyd, 1977).

Class **BRANCHIOPODA** Latreille, 1817

Subclass **PHYLLOPODA** Preuss, 1951

Order **DIPLOSTRACA** Gerstaecker, 1866

Suborder **CLADOCERA** Latreille, 1829

Small crustaceans distinguished by a bivalved carapace without a hinge, which is fused to two or more of the thoracic segments leaving the head free. Only 4 to 6 trunk limbs, single compound eye and a dorsal cavity below the carapace that serves as a brood pouch where the eggs are incubated. Second antennae with few joints and bearing plumose bristles that aid in locomotion.

Infraorder **CTENOPODA** Sars, 1865

Family **SIDIDAE** Baird, 1850

Genus ***Penilia***

1. 1. ***Penilia avirostris*** Dana **Female**: Body and legs covered by bivalve carapace, antennules of females small and truncated; sensory setae terminal. Head with prominent rostral points in females. The entire free carapace edged with spines; a larger spine at the inferoposterior angle of carapace. Six pairs of legs, the most posterior ones reduced. Length 0.5 to 1.2 mm; (Fig. 1.a & b).

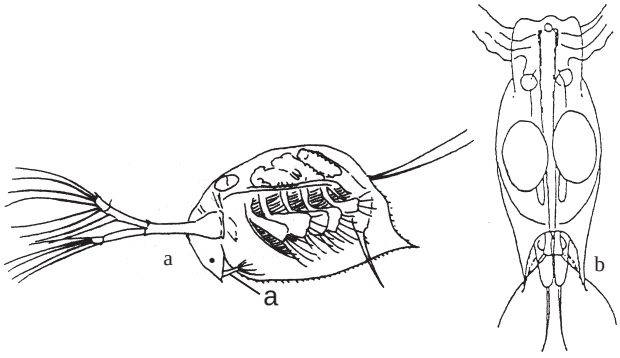

Fig. 1. *Penilia avirostris.* (a). Female with parthenogenic embryos, lateral view (b) Gamogenic female with resting embryos, dorsal view. (Egloff *et. al.*, 1997).

Male: Antennules as long as the carapace in adult males. Head round in males; strong hook at the distal end of the first leg. Copulatory organs longer than postabdomen in adults. Length 0.7 to 0.9 mm; (Fig. 2. a & b).

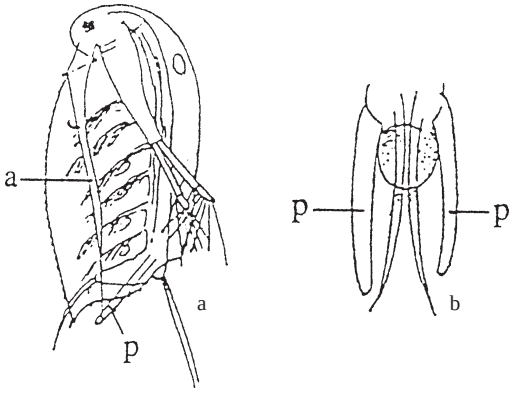

Fig. 2. *Penilia avirostris.* (a). Male lateral view. (b) Male ventral view. a - Antennule; p - penis. (Egloff *et. al.*, 1997).

Genus ***Diaphanosoma***

1. ***Diaphanosoma sarsi*** Fischer **Female**: Head large, without rostrum, fornix and ocellus; eyes large with lenses, cervical sinus present. Antennules small, truncated; with terminal olfactory setae and a slender flagellum. Dorsal ramus of antenna 2-segmented, ventral ramus 3-segmented. Postabdomen narrow without anal spines. Claw with three basal spines; length 0.8-0.94 mm; (Fig. 1. a).

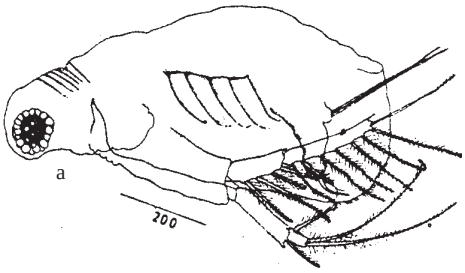

Fig. 1. *Diaphanosoma sarsi* Fischer (a). Female lateral view. (Michael & Sharma, 1988).

Male: Smaller than female; long antennules of length 0.33mm; olfactory setae laterally placed and hook on 1st foot. Average length of male 0.77mm.

Infraorder **ONYCHOPODA** Sars, 1865

Family **PODONIDAE** Mordukhai-Boltovskoi, 1968

Genus ***Evadne***

1. ***Evadne tergestina*** Claus **Female**: Body and legs not covered by bivalve carapace. Carapace converted into large brood sac, junction of head and body without dorsal depression and the body is oval in shape. Brood pouch from hemispherical to semi-oval in shape. Length 1.0 mm in females; (Fig. 1. a & b).

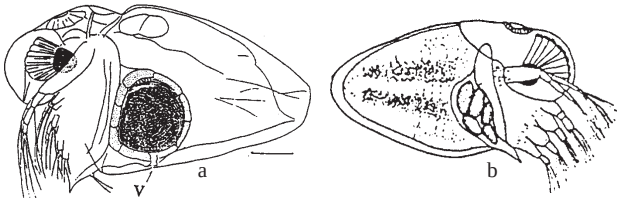

Fig. 1. *Evadne tergestina* Claus. (a) Gamogenic female with resting embryos, lateral view. (b) Female with parthenogenic eggs, lateral view. (1.b Wickstead, 1965; Egloff *et. al.,* 1997).

Male: Length 0.8 mm. (Fig. 2. a).

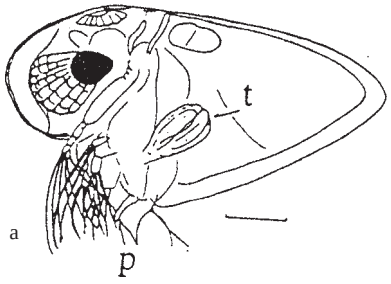

Fig. 2. *Evadne tergestina* Claus. (a) Male lateral view. t - testes; v - vagina. (Egloff *et. al.,* 1997).

Class **MALACOSTRACA** Latreille, 1802

Subclass **EUMALACOSTRACA** Grobben, 1892

Superorder **PERACARIDA** Calman, 1904

Order **MYSIDA** Haworth, 1825

Family **MYSIDAE** Haworth, 1825

Small shrimp like crustaceans with a shield like carapace loosely covering the posterior part of thorax, not fused with more than three thoracic segments. Thoracic limbs with well developed exopodites, the 1st are the maxillipeds and the 2nd gnathopod. A rostrum and stalked eyes. Endopods of uropod with statocyst except some deep water forms. Eggs are carried in a brood pouch (marsupium) formed by the oostegites of the endopodites of thoracic limbs. Illustrations on the external morphology and appendages of a mysid are given in Fig.1.a & b.

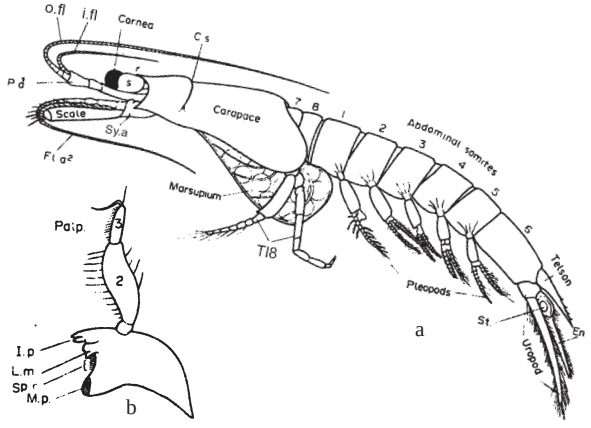

Fig. 1. (a) External morphology and appendages of a female mysid, lateral view. (pd): peduncle of a 3-segmented antennule with outer (o.fl.) and inner (i.fl) flagella; (sya): sympod of antenna; (fla^2): flagellum; (s): stalk of eye; (r): rostrum; (c.s): cervical sulcus; (7 and 8): 7th and 8th thoracic somites; (t.l^8): 8th thoracic limb; (en): endopod of uropod; (st): statocyst.

(b) Mandible with three segmented palp. (I.p.): incisor process; (L.m.): lacinia mobilis; (Sp.r): spine row: (M.p.): molar process. (Reymont, 1983).

Genus ***Mesopodopsis***

1. ***Mesopodopsis orientalis*** (W.M.Tattersall): Rostrum very short, perfectly semicircular. Thoracic limbs 3 to 8 with 5 to 9 carpopropodal segments. 4th pleopod of **male** with endopod

nearly twice as long as the 1st segment of exopod, the spines on the 3rd exopod segment not spirally twisted. Telson with 4 lateral spines (Fig. 1. a), narrow distal part more than one-third the total length. Observed in mangroves and estuarine environments. Length 7 mm.

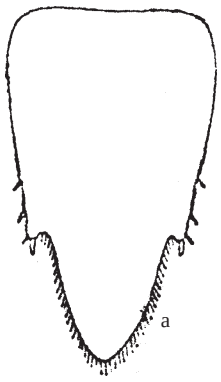

Fig. 1. *Mesopodopsis orientalis* (W.M.Tattersall) (a) Female telson. (Pillai, 1965).

2. Mesopodopsis zeylanica Nouvel: Frontal plate angular, anterolateral angles produced into curved spines. Thoracic limbs 3 to 8 with 6 carpopropodal segments. 4th pleopod of **male** very long reaching far beyond the tip of telson, endopod very small, only half as long as the 1st segment of exopod, 3rd exopod segment with 2 long spines, the shorter of the two barbed and the longer spirally twisted. Telson with 4 lateral spines (Fig. 2.a), narrow distal part one-third the total length, armed with 50 to 55 teeth. Endopod of uropod without spine below statocyst. Length 5.6 mm.

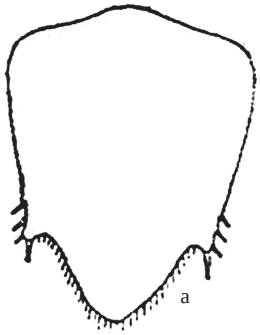

Fig. 2. *Mesopodopsis zeylanica* Nouvel (a) Female telson. (Pillai, 1965).

Genus ***Gastrosaccus***

1. *Gastrosaccus dunckeri* Zimmer **Male**: Shallow water form, peculiar bulging of the basal part of the eyestalk is characteristic. Posterior border of carapace with a pair of large forwardly directed lobes larger than those of any other species. Endopod of third pleopod of male 8-segmented, exopod 4-segmented, 4th segment with 2 subequal spines, the longer with a few strong barbs. Endopod of uropod with 18 spines. Telson with 15 lateral spines, some of them at intervals smaller than the adjacent ones, 2 spineless areas between the 1 st 2 and last 2 lateral spines (Fig. 1. a, b, c, d, e & f).

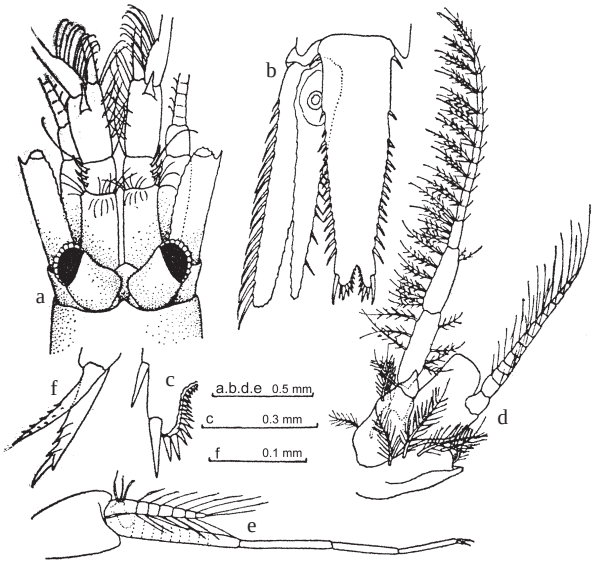

Fig. 1. *Gastrosaccus dunckeri* Zimmer (a) Male anterior part. (b) Male posterior part. (c) Male apical lobe of telson. (d) Male 8th thoracic limb. (e) Male 3rd pleopod. (f) Male 3rd pleopod tip of exopod. (Pillai, 1965).

Another common species of ***Gastrosaccus*** (**Female**) is also represented in Fig. 2. a, b & c.

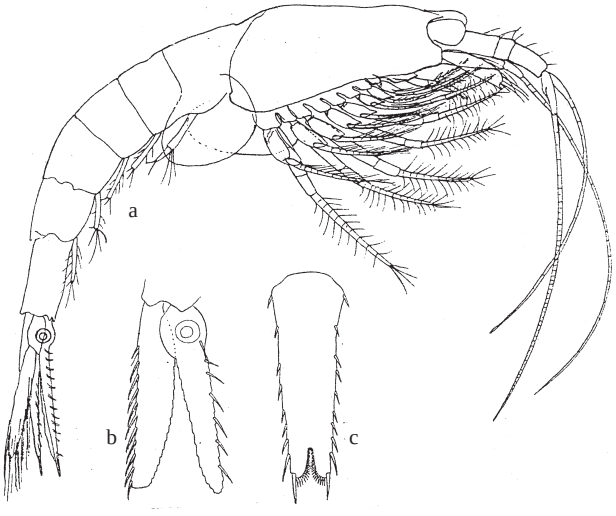

Fig. 2. *Gastrosaccus* sp (a) Female lateral view. (b) Female uropods. (c) Female telson. (Dakin and Colefax, 1940).

Order **AMPHIPODA** Latreille, 1816

Amphipods are generally small with a bilaterally compressed body, without carapace, sessile eyes, biramous antennules, pereopods 2-3 subchaelate and with 3 pairs of backward pointing uropods present on the tail. Found in a diversity of habitats from the upper shore to great depths. Illustrations on the external morphology and appendages of an amphipod are in Fig. 1 a.

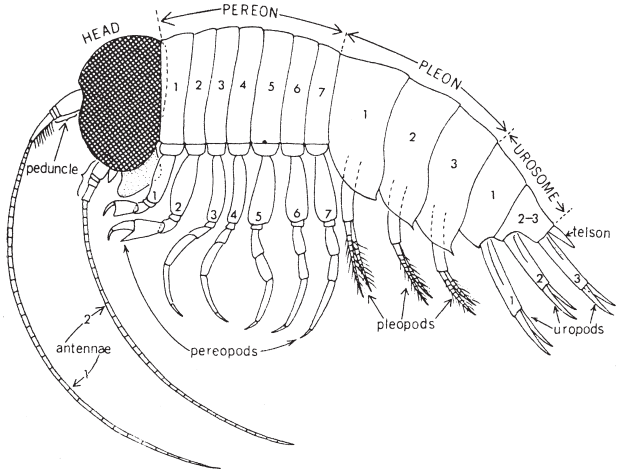

Fig. 1.a. External morphology and appendages of an amphipod, lateral view. (Richmond, 1997).

Suborder **GAMMARIDEA** Latreille, 1802

Family **GAMMARIDAE** Latreille, 1802

Gammaridae (Fig. 1.a) include the bulk of the large shallow water species while the hyperiidae (Fig. 1.b) are the transparent planktonic forms which live at all depths and also as a commensal (Fig. 1.b & 1. c).

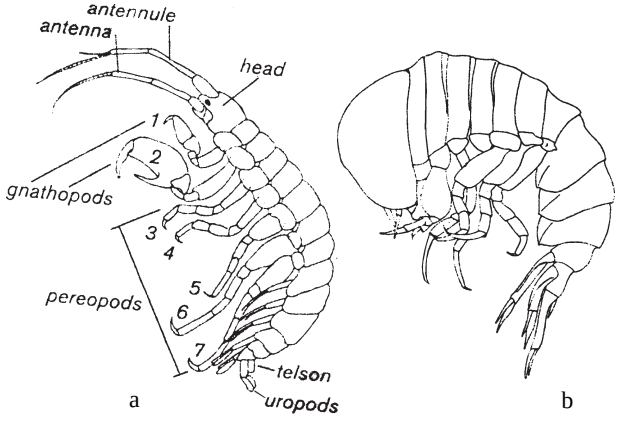

Fig. 1.(a) External morphology and appendages of a gammarid and (b) hyperrid amphipods, lateral views. (Richmond, 1997).

Family **MELITIDAE** Bousfield, 1973

Genus ***Melita***

1. ***Melita zeylanica*** Stebbing **Male**: Head without a rostrum, antero-inferior angle produced into an independent rounded lobe. Peraeon segments and first 3 pleon segments subequal. Coxal plates 1-4 with dorsal spinules. Posterolateral angles of the third pleon segment hook like. First antenna with 23-segmented flagellum and accessory flagellum is 4-segmented. Flagellum of second antenna is 7-8 segmented. Found very often in the mangroves (Fig. 1. a, b, c, d & e).

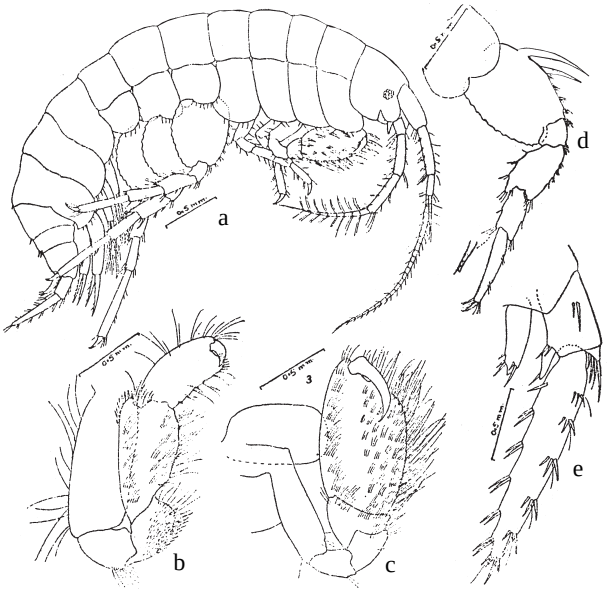

Fig. 1. *Melita zeylanica* Stebbing (a) Male, lateral view. (b) First pereiopod (c) Second pereiopod (d) Fifth pereiopod (e) Third uropod and telson. (Pillai, 1961).

Order **ISOPODA** Latreille, 1817

Isopods with dorsoventrally compressed body, lacking a carapace, eyes sessile, body is divided into narrowed segments – 7 thoracic and 6 abdominal, the antennules and antennae are always uniramous. Illustrations on the external morphology and appendages of an isopod are given in Fig. 1. a & b.

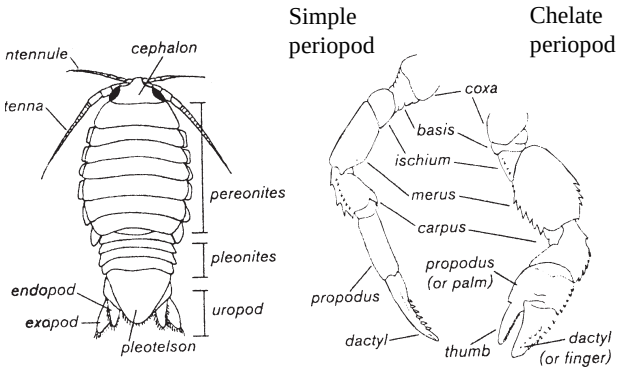

Fig. 1. External morphology and appendages of an isopod (a) dorsal view (b) Chelate and Simple pereiopod. (Richmond, 1997).

Suborder **FLABELLIFERA** Sars, 1882

Family **CIROLANIDAE** Dana, 1852

Genus: ***Cirolana***

1. ***Cirolana fluviatilis*** Stebbing: Body comparatively narrow, two and a half to 3 times as long as broad. Peraeon segments 4-7 with a row of teeth along the posterior border, 7th segment with 13 teeth. Pleon segments 3-5 also with a row of teeth, 11 on 4th and 5 on 5th; the median tooth on each segment larger than the others. Telson triangular, with nearly straight lateral borders. Dorsal side with 2 submedian teeth near the base followed by two parallel longitudinal rows of 3-4 denticles forming a pair of ridges.

Third segment of first peraeopod with 2 blunt teeth, 4th segment with 4, 5th segment not immersed and with a large curved blunt distal tooth.

Endopod of uropod distally rounded and exopod narrow. Colour semitransparent lemon yellow, with slight greenish tint. The tubercles turn rosy in spirit.

Very common in the estuarine regions of Kerala and Chilka lake. Sparingly obtained at Madras and Visakhapatnam. This species was reported from Vishakhapatnam as ***C. pleonastica***, but on re-examination the material was found to be ***C. fluviatilis***. Length 9.0 mm; (Fig.1. a & b).

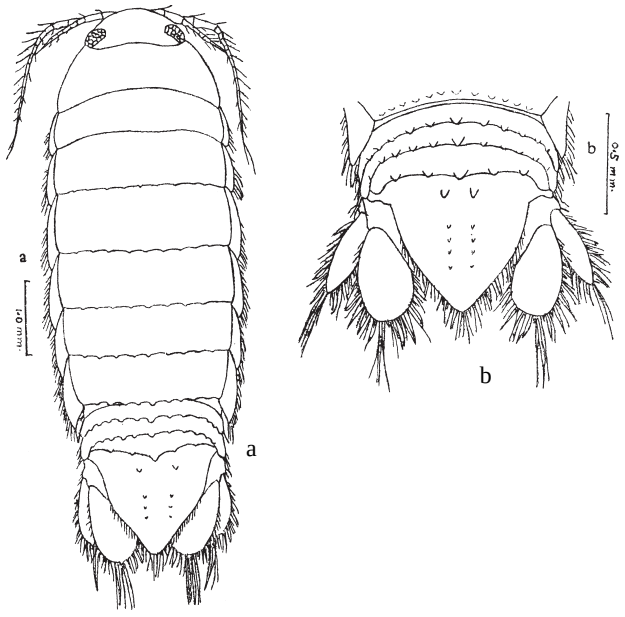

Fig. 1. *Cirolana fluviatilis* Stebbing (a) Female dorsal view. (b) Pleon and telson. (Pillai, 1961).

Family **SPHAEROMATIDAE** Latreille, 1825

Body oval-convex with pleon of two distinct free somites including telson. 1st antennae with peduncle of 3 articles and 2nd antennae with peduncle of 5 articles. Uropods lateral, exopod free and movable, endopod attached to peduncle immovable. The most important character of identification is the number and arrangement of tubercles on the posterior part of the body. Another obvious characteristic of this family is the ability to roll into a sphere when disturbed.

Genus ***Sphaeroma***

1. ***Sphaeroma terebrans*** Bate: Body elongate, oblong, broadest at the sixth segment. Posterior half of dorsal side coarsely granular, each granule carrying a bunch of long hairs. Border of segments hairy. Second peraeon segment shortest and fourth longest. Segments 3-7 with a transverse ridge placed in the anterior half on segment 3 but shifting successively backwards on the succeeding segments and becoming posterior submarginal on the seventh segment. Peraeon segments 5-7 with 4 equidistant posterior submarginal tubercles each carrying a bunch of

long stiff hairs, submedian pair slightly longer than the lateral; some specimens with 4 indistinct tubercles on the fourth segment also. Composite pleon segment equal to the seventh peraeon segment, with 4 large tubercles as on the peraeon. Lateral parts with 3 oblique sutures. **Telson** - A broad based triangle, proximal median part bulged. The proximal region with 4 tubercles similar to those on the pleon and peraeon. Dorsal side of pleon and telson with pustules of various sizes, surmounted by hairs, giving the body a coarsely granular appearance. The successive tubercles on the peraeon, pleon and telson fall into 4 equidistant longitudinal rows.

Abundant in estuarine habitats, a true borer, body dirty brown grey, found in association with ***S. annandale****i*, and very common in mangrove areas, length 15.3mm; (Fig. 1.a & b).

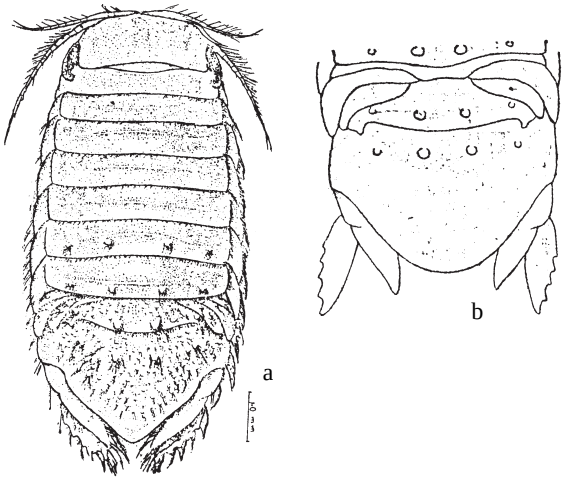

Fig. 1. *Sphaeroma terebrans* Bate (a) dorsal view (b) Pleon and telson. (Pillai, 1961).

2. *Sphaeroma annandalei* Stebbing: Body elongate, oblong, sides parallel. Peraeon segments subequal, each except the first with a transverse ridge. The ridges on segments 2-4 indistinct, on fifth very prominent, those on sixth and seventh broken up into 4 pairs of transversely elongated tubercles; tubercles of seventh segment more prominent, submedian pairs are larger.

Telson - Distal border semicircular, dorsal side proximately bulged and with 2 pairs of submedian tubercles followed by a median tubercle and flanked by 3 tubercles falling into a longitudinal row on either side. The median tubercle is generally with 3 small tubercles on either side. In large specimens the telsonic border is proximally ridge-like and distally crenulate and slightly curved upwards.

Body dark grey, with slight mottling. True timber borer, abundant in the backwater systems of India. Heaviest attack in the intertidal region, length 14.2 mm; (Fig. 2. a & b).

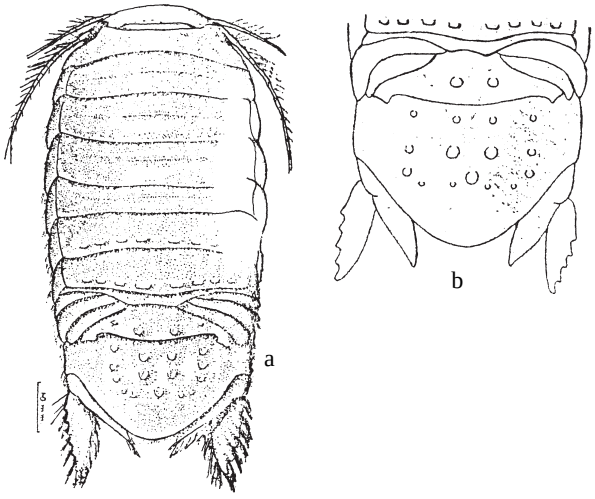

Fig. 2. *Sphaeroma annandalei* Stebbing (a) dorsal view (b) Pleon and telson. (Pillai, 1961).

3. *Sphaeroma annandalei travencorensis* Pillai: Body perfectly oblong, anterior border or cephalon prominently trilobed, antero-lateral borders raised and ridge-like. Each peraeon segment with a transverse ridge, the posterior ones broken up into 4 pairs of transversely elongated tubercles, those on seventh segment very high and wedge - shaped.

Pleon with 4 tubercles. Proximal middle part of telson with 5 tubercles but the lateral longitudinal row is composed of only 2 tubercles. The first submedian pair is slightly smaller than the second. The whole surface of telson is pustulose. Distal border perfectly rounded and ridge-like, the margins with blunt spines. Body grey with isolated brick red patches on the border of segments. Found abundant at Cochin backwater system, length 14.6 mm; (Fig. 3. a & b).

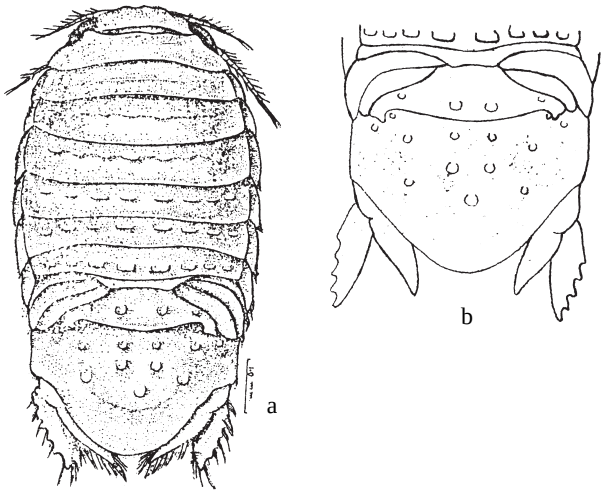

Fig. 2. *Sphaeroma annandalei travencorensis* Pillai (a) dorsal view (b) Pleon and telson. (Pillai, 1961).

Order **TANAIDACEA** Dana, 1849

Suborder **TANAIDOMORPHA** Sieg, 1980

Superfamily **TANAOIDEA** Dana, 1849

Family **TANAIDAE** Dana, 1849

Tanaidaceans inhabit mostly marine and brackish water environments occur in the estuaries of the east and west coasts of India and in mangroves. These epibenthic organisms enjoy worldwide distribution, high fecundity and short generation time. Their importance in estuarine shrimp farms as fodder organisms and as indicators of environmental health has been recognized recently.

Genus *Tanais*

1. Tanais philetaerus Stebbing **Male**: Body slightly narrowing towards the posterior end, head pear shaped, anterior part forming a narrow 'neck' behind the eyes. 1st free peraeon segments short, its anterolateral corners pointed. Pleon 5 segmented, 3rd and 4th segments together equal to the 2nd in length. 5th segment triangular and posteriorly cleft segments 1-3 with a dorsal transverse row of setae. 1st antenna 4-segmented, 2nd antenna 5- segmented carrying a stout tooth. Uropods 4-segmented, almost as long as pleon, 1st segment shortest.

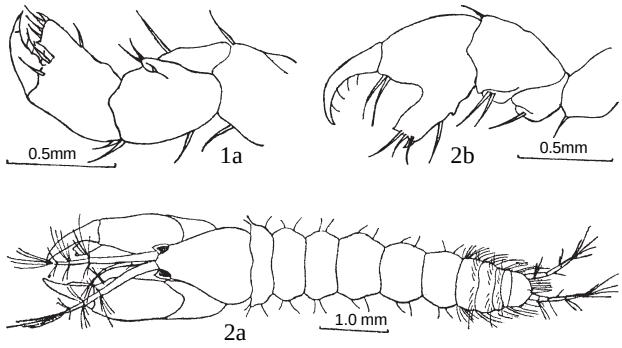

Fig. 1. *Tanais philetaerus* Stebbing (a) Female 1st pereiopod 2. (a) Male dorsal view. (b) Male 1st pereiopod. (Pillai, 1961).

Body dark grey, with profusely branched chromatophores forming patterns at the anterior and posterolateral aspects of the head and the posterior and lateral parts of the body segments. This species is very common in the Kerala backwaters and in the Mangalavanam Mangrove areas. Body length 4.0 mm. **Female's** 1st pereiopod is shown in Fig.1. a and **male's** dorsal view and first pereiopod in Fig. 2. a & b.

2. *Apseudes chilkensis* Chilton **Male:** Body length ranged from 5.15 to 7.5 mm. The transparent membraneous marsupial pouch is formed of the four pairs of oostegites arising from the base of the 2nd to 5th pairs of pereiopods. Sexual dimorphism is seen in chela of the advanced stages. Size and structure of chelae, 7th pair of pereiopods, pleopods, presence or absence of oostegites are helpful in identifying

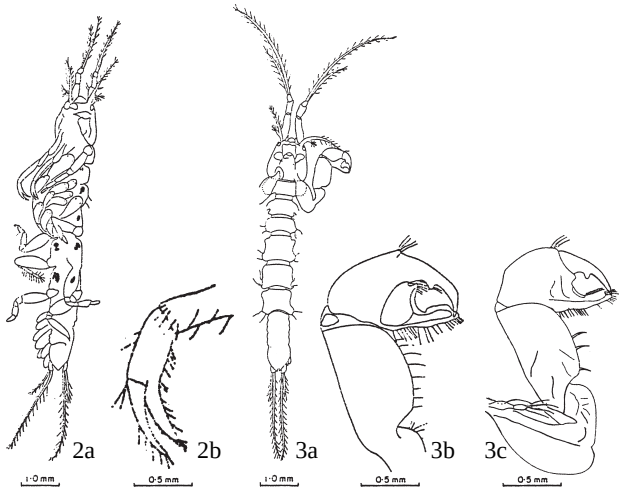

Fig. 2. *Apseudes chilkensis* Chilton (a) Female ventro-lateral view. (b) Female chela. 3. (a) Male dorsal view. (b) Male chela. (c) Male cheliped. (Vengayil *et. al.*, 1988).

the animal. It is a common tanaid from the backwaters of Kerala. Diagnostic characters of **female** are shown in Fig. 2. a & b and those of **male** in Fig. 3. a, b & c.

Superorder **EUCARIDA** Calman, 1904

Order **DECAPODA** Latreille,1802

This order comprises shrimps, crabs, and lobsters. The carapace covers the entire thorax. First 3 pairs of the 8 thoracic limbs are maxillipeds, the first two often bearing the claw or chaela and the eyes stalked. Eggs are borne on the pleopods. The shrimps have developmental stages from eggs, nauplii, protozoeae, mysis, postlarvae and juveniles to adult.

Suborder **DENDROBRANCHIATA** Bate, 1888

Superfamily **SERGESTOIDEA** Dana,1852

Family **LUCIFERIDAE** DeHaan, 1849

Members with short rostrum, shorter than the eye stalk in adults; the body is strongly compressed and there are no gills.

Genus ***Lucifer***

Anterior part of the cephalothorax considerably elongated bearing the long stalked eyes. Body slender and very much transparent. 4th and 5th pereiopods absent. Females loosely carry clusters of eggs on the third pereiopods. Length of eye stalks, spines on the telson; characteristics of petasma and length of the first antennular joint are important characters of identification. Larval forms and adults very common in nearshore waters (Fig. 1. a, b, c & d).

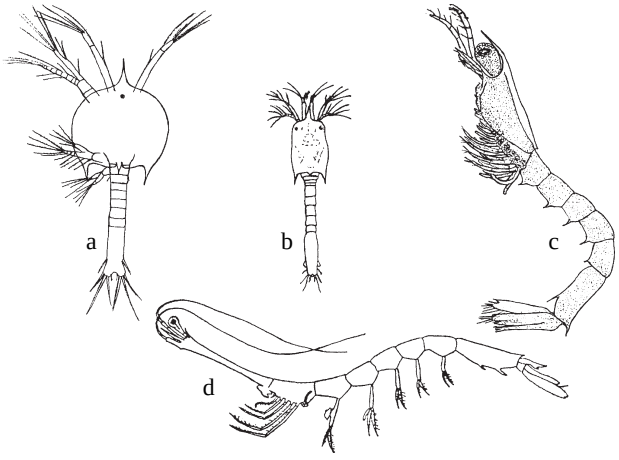

Fig. 1. *Lucifer* (a&b) Protozoeal stages. (c) Mysis stage. (d) Adult. (1.d Wickstead, 1965; Dakin and Colefax, 1940).

1. ***Lucifer hanseni*** Nobili **Female**: Rostrum short and acute. Short eyestalks and the 1st antennular joint slightly longer than the eyes. Length of female 1.2 cm; (Fig. 1. a, b & c).

Fig. 1. *Lucifer hanseni* Nobili (a) Female lateral view (b) Female abdominal Segment showing lateral spine (c) Female terminal part of exopod of uropod. (Dakin and Colefax, 1940).

Male: Telson with prominent protruberances on ventral surface. Terminal portion of petasma sheath acute, processus ventralis slender needle with acute end. Length of male 0.9 cm; (Fig. 2. a, b, c, d & e).

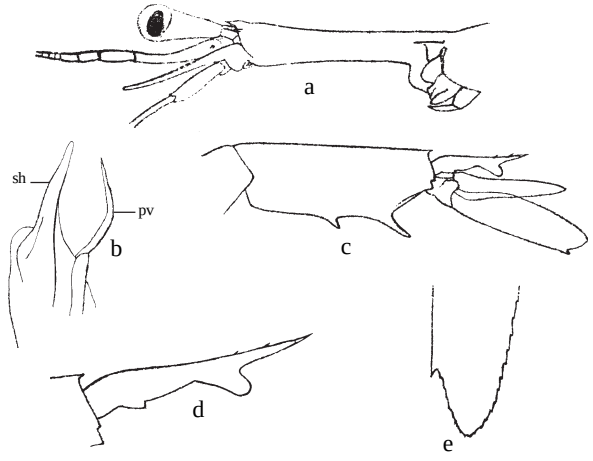

Fig. 2. *Lucifer hanseni* Nobili (a) Male anterior half of cephalothorax lateral view (b) Male terminal portion of petasma inner side view, processus ventralis turned out of the sheath (c) Male sixth abdominal segment, uropods and telson lateral view (d) Male telson lateral view showing ventral protruberance (e) Male terminal part of exopod of uropod. (Hansen, 1919).

Family **SERGESTIDAE** Dana, 1852

The body is moderately compressed and gills are present.

Genus ***Acetes***

Male: Lower antennular flagellum and its three basic structures namely, a 2-segmented basal shaft, an inner multi-segmented main branch and the outer clasping spines are the main diagnostic characters including the petasma. **Female**: Coxa-basis of 3rd pereiopod and last thoracic sternum of female are also taken into account for identification purposes. Larvae, juveniles and adults are commonly found in the samples (Figs. 1. a, b & c).

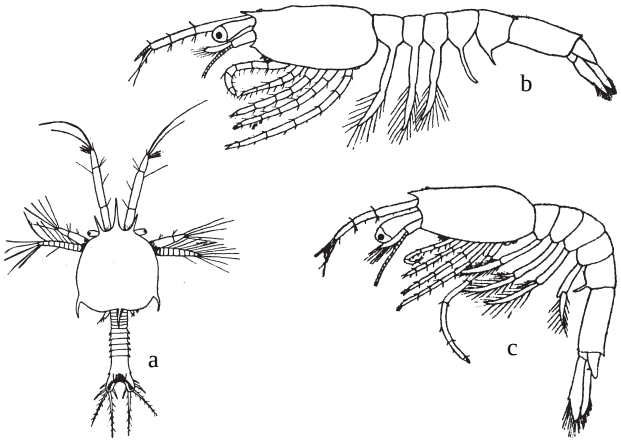

Fig. 1. *Acetes* (a) Protozoeal stage. (b) Post larval stage. (c) Juvenile (Rao, 1968).

1. ***Acetes indicus*** H.Milne Edwards: Large procurved tooth between 1st pair of pleopods present. Basis of 3rd pereiopods with disto-mesial tooth; petasma without coupling folds; 3rd thoracic sternum of **female** with + shaped furrow (Fig. 1. a - e) and (Fig. 2. a - g).

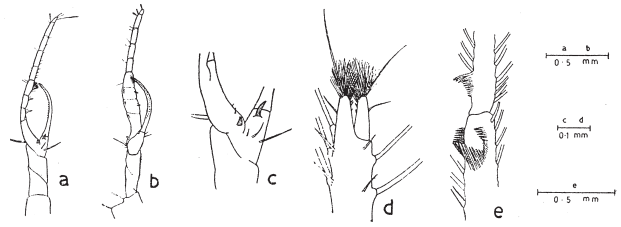

Fig. 1. *Acetes indicus* H. Milne Edwards, (a) Male right lower antenular flagellum dorsal view. (b) Male right lower antennular flagellum outer view. (c) Male basal shaft-main branch-clasping spine junction enlarged. (d) Male chela of 1st pereiopod. (e) Male carpus-propodus of 1st pereiopod showing clasping organ. (Ravindranath, 1980).

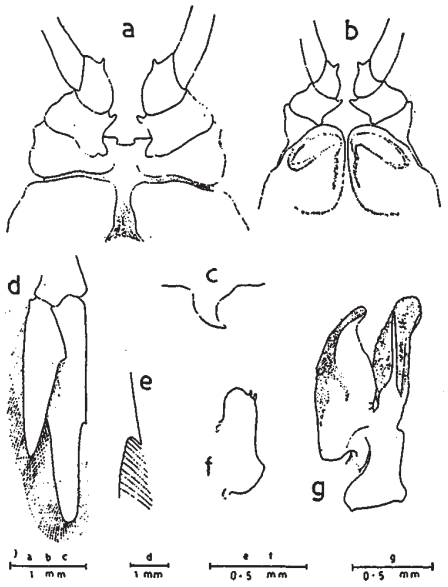

Fig. 2. *Acetes indicus* H. Milne Edwards, (a) Female coxa-basis of 3rd pereiopods and last thoracic sternum. (b) Male coxa-basis of 3rd pereiopods and genital coxae. (c) Male procurved tooth (found between 1st pair of pleopods). (d) Male right uropod. (e) Male marginal tooth of uropodal exopod enlarged. (f) Male appenxit masculina. (g) Male right petasmal half in ventral view. (Ravindranath, 1980).

2. ***Acetes japonicus*** Kishinouye: Apex of telson broadly rounded; 1st segment of the main branch of the lower antennular flagellum of **male** without

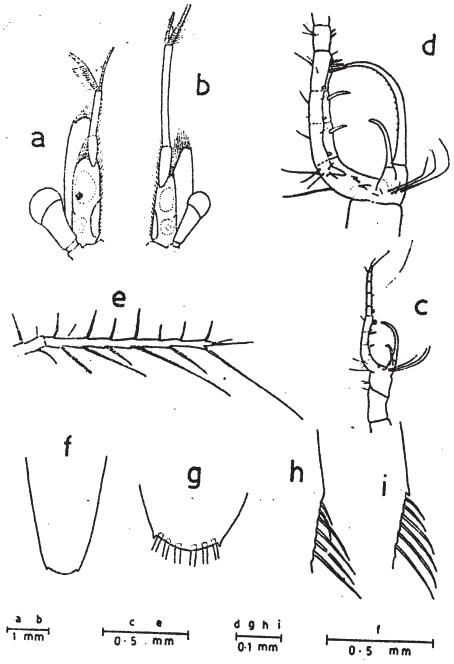

Fig. 1. *Acetes japonicus Kishinouye.* (a) Female left anterior half. (b) Male right anterior half. (c) Male right lower antennular flagellum. (d) Male middle portion enlarged. (e) Male distal segment of 3rd maxilliped. (f) Male distal portion of telson. (g) Male telson tip enlarged. (h) Male uropodal exopod without marginal tooth. (i) Male uropodal exopod with marginal tooth. (Ravindranath, 1980).

any hook-like protruberance; processus ventralis needle-like, originating from the middle of pars media of petasma; 3rd thoracic sternum of female produced posteriorly in the form of a rectangular plate (Fig. 1. a - i.) and (Fig. 2. a - f).

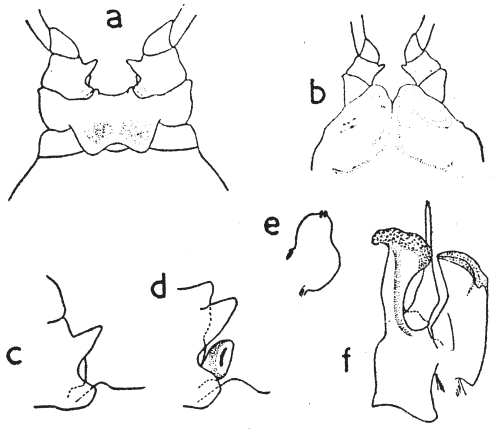

Fig. 2. *Acetes japonicus Kishinouye.* (a) Female coxa-basis ot 3rd pereiopods and last thoracic sternum. (b) Male coxa-basis of 3rd pereiopods and genital coxae. (c & d) Female coxa of right 3rd pereiopod showing genital pore. (e) Male appendix masculina. (f) Male left petasmal half ventral view. (Ravindranath, 1980).

3. ***Acetes erythraeus*** Nobili: Large procurved tooth between 1st pair of pleopods present. Basis of 3rd pereiopods without disto-mesial tooth; petasma without coupling folds; 3rd thoracic sternum of **female** plain (Fig. 1. a - i.) and (Fig. 2. a - e).

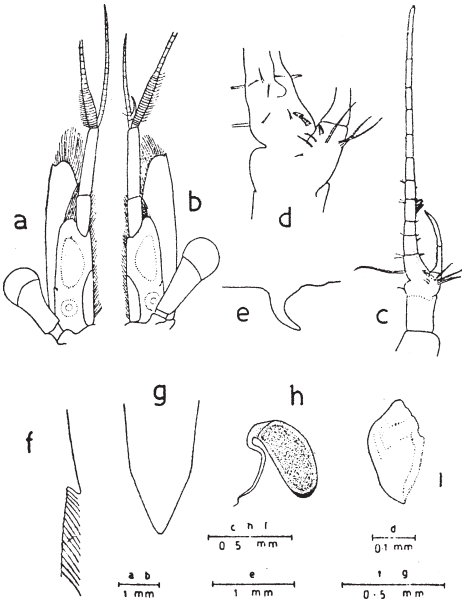

Fig. 1. *Acetes erythraeus* Nobili. (a) Female left anterior half. (b) Male right anterior half. (c) Male right lower antennular flagellum. (d) Male basal shaft-main branch-clasping spine junction enlarged. (e) Male procurved tooth found between 1st pair of pleopods. (f) Male marginal tooth of uropodal exopod. (g) Male telson tip. (h) Male intact spermatophore. (i) Female mass (one half) found below the sternum between 3rd pereiopods in mature individuals. (Ravindranath, 1980).

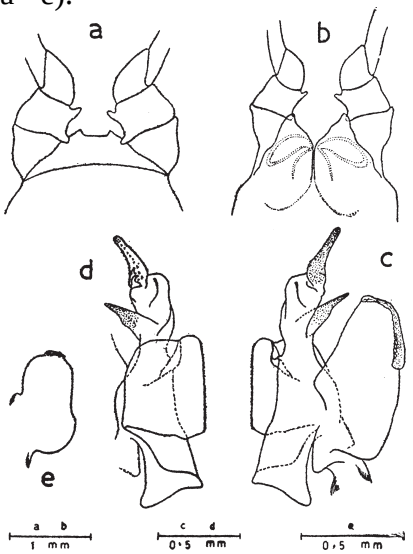

Fig. 2. *Acetes erythraeus* Nobili. (a) Female coxa-basis of 3rd pereiopods and last thoracic sternum. (b) Male coxa-basis of 3rd pereiopods and genital coxae. (c) Male left petasmal half ventral view. (d) Male left petasmal half excluding pars externa dorsal view. (e) Male appendix masculina. (Ravindranath, 1980).

4. ***Acetes sibogae*** Hansen: Large procurved tooth between 1st pair of pleopods absent. Apex of telson obtusely angular (without any teeth); the

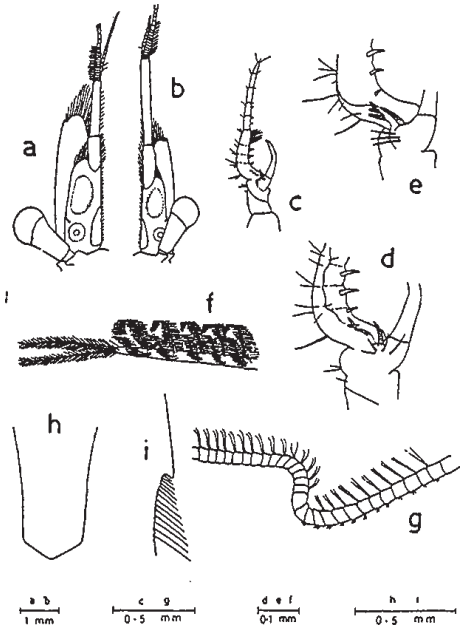

Fig. 1. *Acetes sibogae* Hansen. (a) Female left anterior half. (b) Male right anterior half. (c) Male right lower antennular flagellum. (d&e) Male basal shaft-main branch-clasping spine junction enlarged. (f) Male tip of antennal flagellum showing setation. (g) Male flexture between proximal and distal portions of antennal flagellum. (h) Male distal portion of telson. (i) Male marginal tooth of uropodal exopod. (Ravindranath, 1980).

lower antennular flagellum of **male** with 1 clasping spine; petasma with coupling folds; 3rd thoracic sternum of **female** roughly rectangular and plain (Fig. 1. a – i) and (Fig. 2. a - f).

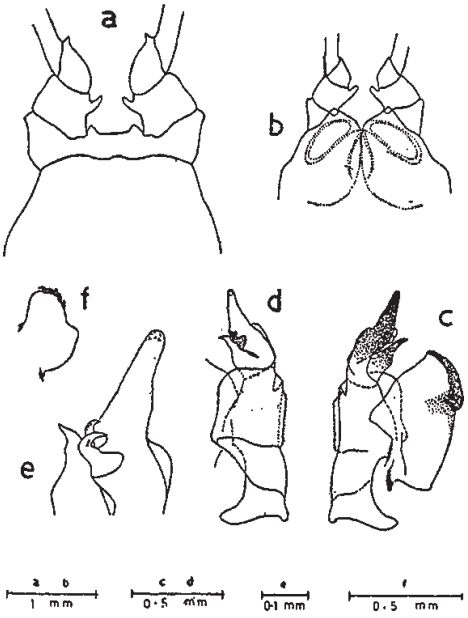

Fig. 2. *Acetes sibogae* Hansen. (a) Female coxa-basis of 3rd pereiopods and last thoracic sternum. (b) Male coxa-basis of 3rd pereiopods and genital coxae. (c) Male left petasmal half ventral view. (d) Male left petasmal half excluding pars externa dorsal view. (e) Male capitulum enlarged dorsal view. (f) Male appendix masculina. (Ravindranath, 1980).

Superfamily **PENAEOIDEA** Rafinesque, 1815

Family **PENAEIDAE** Rafinesque, 1815

Stalked eyes, rostrum elongated, pereiopods 1-3 roughly with equal sized chelae. Telson deeply notched, most species occur over mud or sand bottoms in shallow coastal zones with juveniles entering estuarine areas and mangrove forests.

Genus ***Penaeus***

Mysis: In the mysis stage of ***Penaeus***, carapace with prominent supraorbital, pterygostomial and hepatic spines but antennal spine absent. 5th abdominal segment with a pair of posterolateral spines. Dorsomedian spines present on 4th, 5th and 6th abdominal segments, sometimes on 3rd segment also. Uropod with outer margin of exopod produced into a very prominent distolateral spine followed by fringing setae. Telson with 8+8 setae.

Early postlarvae: Long and slender. 5th abdominal segment with posterodorsal spine. Telson with 8 pairs of setae.

1. Penaeus indicus H. Milne Edwards: Rostrum long with1 or 2 dorsal spines in the **early postlarvae**; supraorbital, pterygostomial and hepatic spines present on carapace. Posterodorsal spines present on the 4th, 5th and 6th and lateral spines on 5th and 6th abdominal segments. Pleopods well developed. Telson rectangular with 8+8 spines; 3 pairs of lateral and 5 pairs of terminal; median notch absent. Illustrations (CMFRI, 1978) on the postlarva I of ***P. indicus*** taken from the laboratory cultured specimens are shown in Fig. 1: a – j.

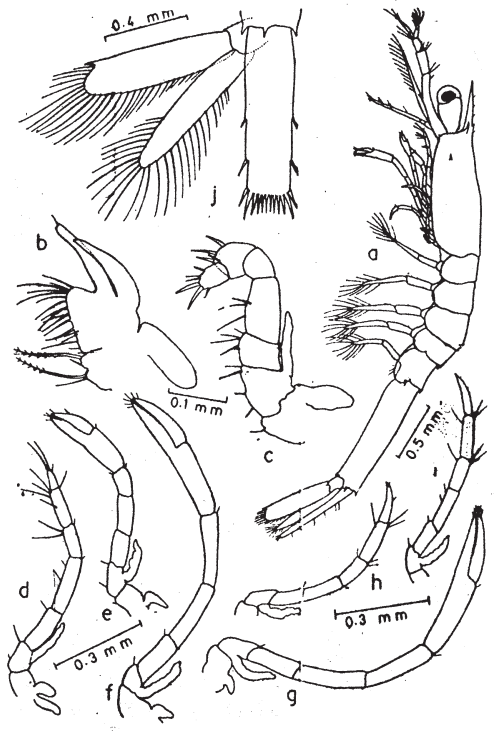

Fig. 1. *Penaeus indicus* H. Milne Edwards. (a) Post larva I lateral view. (b) 1st maxilliped. (c) 2nd maxilliped. (d) 3rd maxilliped. (e) 1st pereiopod. (f) 2nd pereiopod. (g) 3rd pereiopod. (h) 4th pereiopod. (i) 5th pereiopod. (j) Uropod and telson. (CMFRI Bulletin, 1978).

Juveniles of ***P.indicus*** were present commonly in the mangrove areas showing the characteristic of double curvature of the rostrum;

dorsal rostral spines were 8 and the ventral rostral spines varied from 5 to 8; the 1st dorsal rostral spine coincided with the 3rd ventral spine distally from the tip.

Genus ***Metapenaeus***

Mysis: Carapace without supraorbital spine; antennal spine present, pterygostomial and hepatic spines usually absent in mysis I reappear in later stages. Abdominal segments 5 and 6 only with dorsomedian spines; no lateral spines on any segments. Distolateral spine absent on the outer margin of the exopod of uropod in mysis I appear as very small in subsequent stages. Telson with 7+7 spines.

Early postlarvae: Small. rostrum short with 2 dorsal spines and 1 epigastric spine. Hepatic spine present, no supraorbital spine. Posterodorsal spine present only on 6th abdominal segment; no lateral spines on any abdominal segment. Telson with 7 pairs of spines.

1. *Metapenaeus dobsoni* (Miers): Rostrum short and blunt with 2-3 dorsal spines. 5th abdominal segment is devoid of posterodorsal spines. Telson with convex posterior end 7+7 spines; 3 pairs lateral and 4 pairs terminal. Illustrations on the postlarva I of ***M.dobsoni*** are given in Fig. 1: a – k and Fig. 2: a – g.

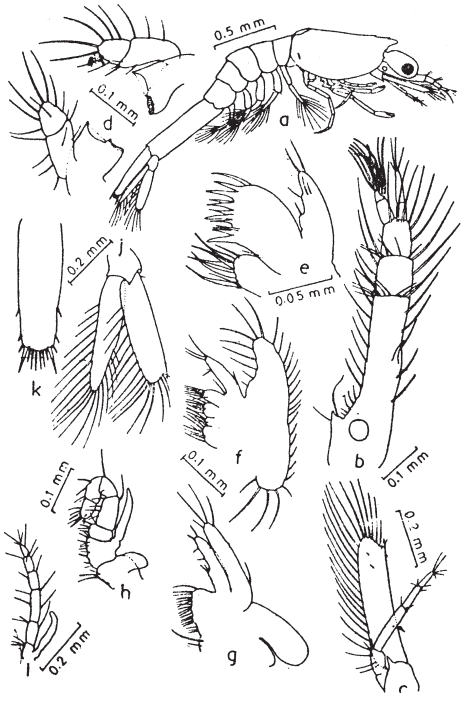

Fig. 1. *Metapenaeus dobsoni* Miers. (a) Post larva I lateral view. (b) Antennule. (c) Antenna. (d) Mandible. (e) Maxillule. (f) Maxilla. (g) 1st maxilliped. (h) 2nd maxilliped. (i) 3rd maxilliped. (j) Uropod. (k) Telson. (CMFRI Bulletin, 1978).

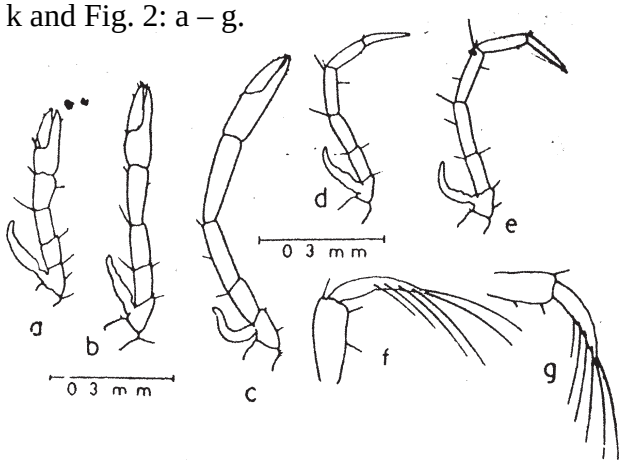

Fig. 2. *Metapenaeus dobsoni* Miers. (a) 1st pereiopod. (b) 2nd pereiopod. (c) 3rd pereiopod. (d) 4th pereiopod. (e) 5th pereiopod. (f) 3rd pleopod. (g) 4th pleopod. (CMFRI Bulletin, 1978).

2. *Metapenaeus monoceros* Fabricius: Rostrum short and sharply pointed with 3 dorsal teeth and 1 epigastric tooth. Telson convex posteriorly bears 7+7 spines; 3 pairs of lateral and 4 pairs of terminal spines. Illustrations on the postlarva I of ***M. monoceros*** are given in Fig. 1: a – m.

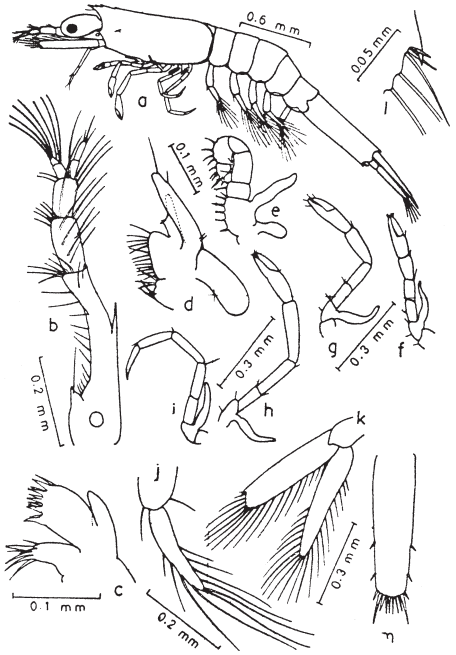

Fig. 1. *Metapenaeus monoceros* Fabricius (a) Post larva 1 lateral view. (b) Antennule. (c) Maxillule. (d) 1st maxilliped. (e) 2nd maxilliped. (f) 1st pereiopod. (g) 2nd pereiopod. (h) 3rd pereiopod. (i) 5th pereiopod. (j) Pleopod II. (k) Uropod. (l) Distolateral tip of the exopod or uropod. (m) Telson. (CMFRI Bulletin, 1978).

Chromatophore pattern on the tail fan has been found to be a reliable and easily observed criterion for the identification of postlarval penaeids from the brackishwater regions (CMFRI,1978). The distinguishing characters of the postlarvae of ***Penaeus indicus, Metapenaeus dobsoni*** and ***M.monoceros*** are illustrated. In ***P. indicus*** telson bears chromatophores in distal half only (Fig. 1. a – d); in ***M. dobsoni*** a prominent chromatophore is present in the middle of each uropod ramus (Fig. 2. a-d).and in ***M.monoceros*** the chromatophores are present on inner rami of uropods while outer rami remain colourless; (Fig. 3. a-d).

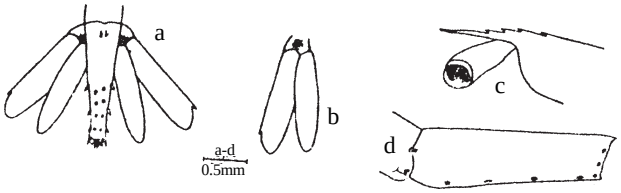

Fig. 1. *Penaeus indicus* (C. L. 1.70 mm) (a) Tail fan. (b) Left uropod. (c) Anterior end of carapace. (d) 6th abdominal segment. (CMFRI Bulletin, 1978).

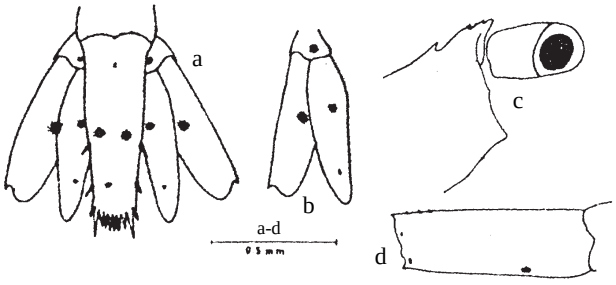

Fig. 2. *Metapenaeus dobsoni* (C. L. 0.89 mm) (a) Tail fan. (b) Left uropod. (c) Anterior end of carapace. (d) 6th abdominal segment. (CMFRI Bulletin, 1978).

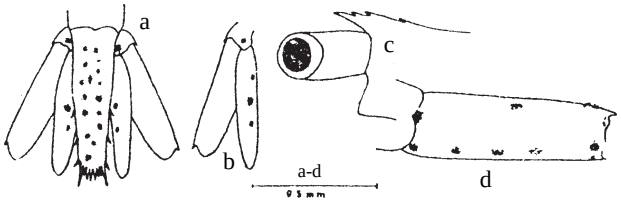

Fig. 3. *M.monoceros* (C. L. 1.0 mm) (a) Tail fan. (b) Left uropod. (c) Anterior end of carapace. (d) 6th abdominal segment. (CMFRI Bulletin, 1978).

Suborder **PLEOCYEMATA** Burkenroad, 1963

Infraorder **ANOMURA** MacLeay, 1838

Superfamily **PAGUROIDEA** Latreille, 1802

Family **DIOGENIDAE** Ortman, 1892

HERMIT CRABS: Most hermit crabs occupy spiraled gastropod shells that protect the soft, elongated and twisted abdomen. Inhabitants of mainly shorelines but occur from land to deep sea. Illustrations on the external morphology, appendages and reproduction in decapod crabs are given in Fig. 1.

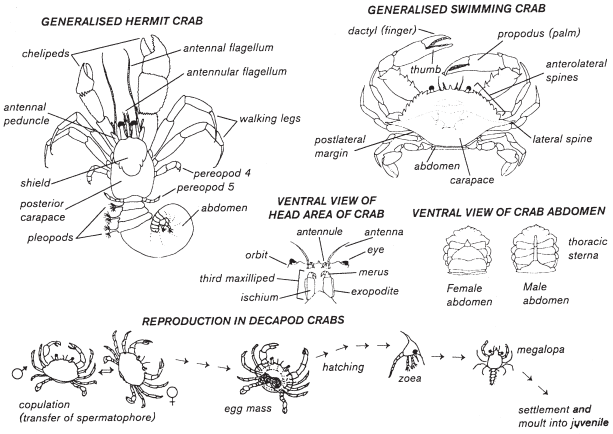

Fig. 1. External morphology, appendages and reproduction in decapod crabs. (Richmond, 1997)

Clibanarius padavensis De Man and ***Diogenes avarus*** Heller are very common in the Indian mangroves.

Genus *Clibanarius*

1. Clibanarius padavensis De Man: **Zoeal stages**: Smooth carapace, rostrum broad and blunt reaching beyond the antennule and antennae. Antennal scale without a terminal spine and abdominal segments are smooth. **Telson**: Broad and triangular with a deep notch on the posterior margin, notch fringed with fine hairs; 1st process generally blunt, fingerlike and situated slightly laterally, 4th telson process reduced to a

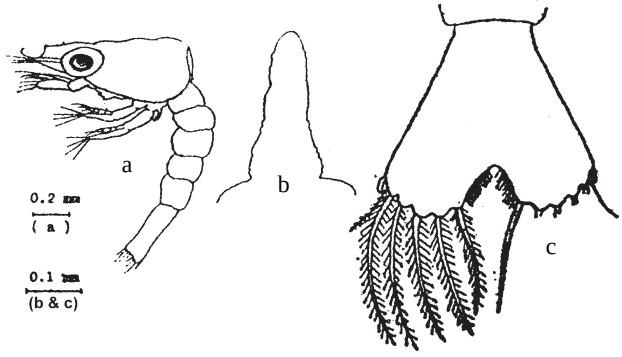

Fig. 1. *Clibanarius padavensis* De Man 1st zoea, carapace length - 0.9 mm; abdomen length - 1.2 mm (a) Entire larva lateral view (b) Rostrum dorsal view. (c) Telson. (Shenoy and Sankolli, 1975).

tubercle in stage 3. Process formula not more than 8+1+8 (Fig. 1: a, b & c; 2: a & b; 3: a & b; 4: a & b).

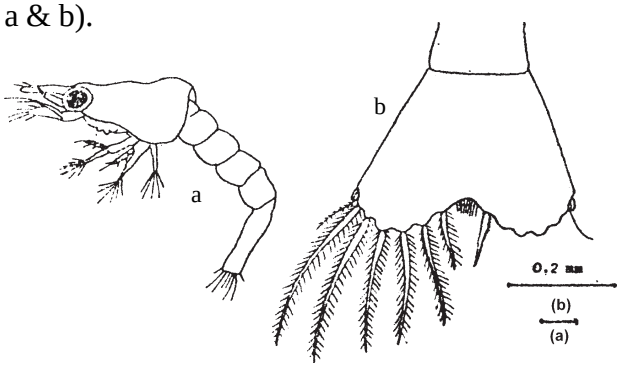

Fig. 2. *Clibanarius padavensis* De Man 2nd zoea, carapace length - 0.9 mm; abdomen length - 1.2 mm (a) Entire larva lateral view (b) Telson. (Shenoy and Sankolli, 1975).

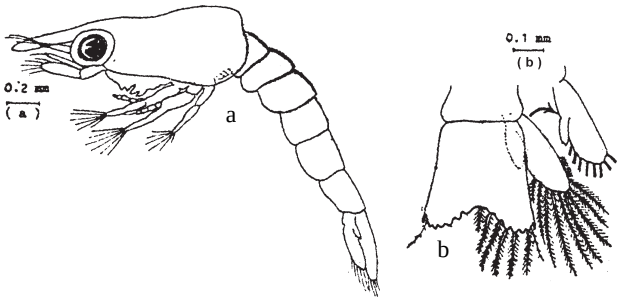

Fig. 3. *Clibanarius padavensis* De Man 3rd zoea, carapace length - 0.9 mm; abdomen length - 1.2 mm (a) Entire larva lateral view (b) Telson and uropod. (Shenoy and Sankolli, 1975).

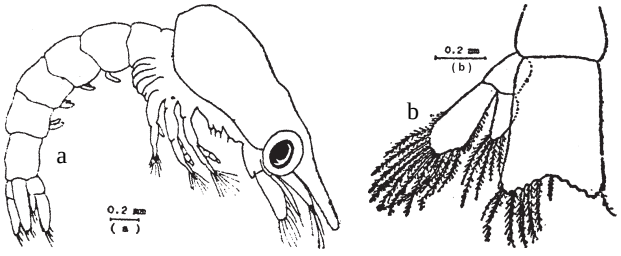

Fig. 4. *Clibanarius padavensis* De Man 4th zoea, carapace length - 0.9 mm; abdomen length - 1.2 mm (a) Entire larva lateral view. (b) Telson and uropod. (Shenoy and Sankolli, 1975).

Glaucothoe: Symmetrical with ocular scales; chelipeds subequal, all the segments smooth; fingers hoofed. **Telson**: Posterior margin with not more than 9 setae (Fig. 5: a & b).

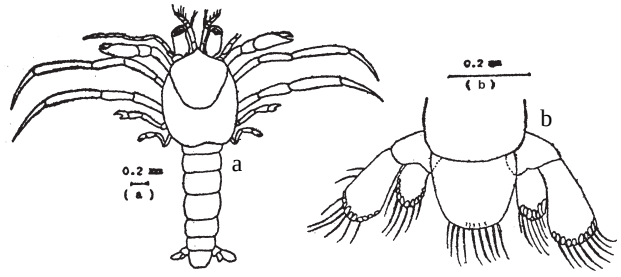

Fig. 5. *Clibanarius padavensis* De Man Glaucothoe. (a) Entire larva dorsal view. (b) Telson and uropods. (Shenoy and Sankolli, 1975).

Genus ***Diogenes***

2. Diogenes avarus Heller: **Zoeal stages**: Eyes sessile and large. Rostrum smooth, pointed reaching well beyond antennule and antenna. Carapace smooth, posterolateral angles rounded. **Telson**: Triangular, broad, posterior margin almost straight with a small median notch. Process formula 7 + 7, 1st a small, sharp spine; 2nd an anomuran hair; 3rd to 7th long plumose setae, 5th process being the longest throughout the zoeal stages. No anal spine. Median notch of posterior margin disappears in later zoeal stages. 5th process continues to be the longest. 4th zoeal stage distinguished by large carapace almost covering the middle of 3rd abdominal segment, segmented uropods. (Fig. 1: a, b & c; 2: a; 3: a & b; 4: a & b).

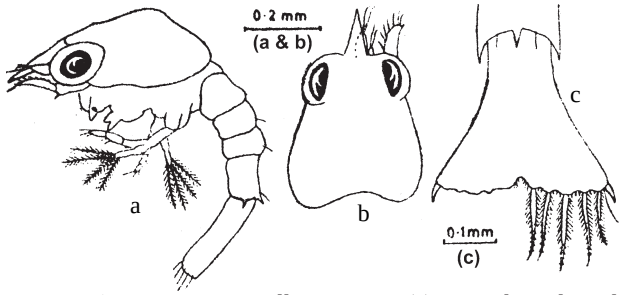

Fig. 1. *Diogenes avarus* Heller 1st zoea (a) Entire larva lateral view (b) Carapace anterior part with rostrum. (c) Telson. (Sankolli and Shenoy, 1975).

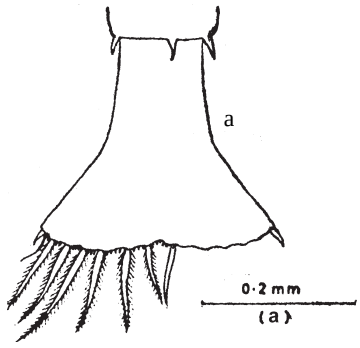

Fig. 2. *Diogenes avarus* Heller 2nd zoea (a) Telson. (Sankolli and Shenoy, 1975).

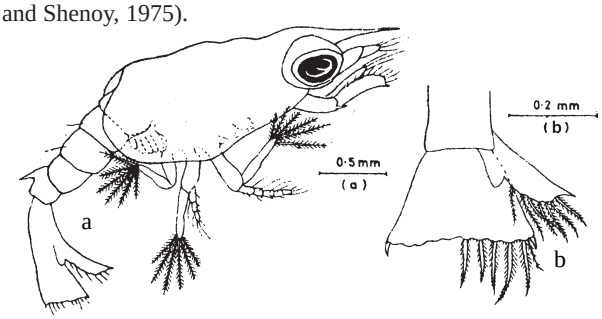

Fig. 3. *Diogenes avarus* Heller 3rd zoea (a) Entire larva lateral view (b) Telson and uropod. (Sankolli and Shenoy, 1975).

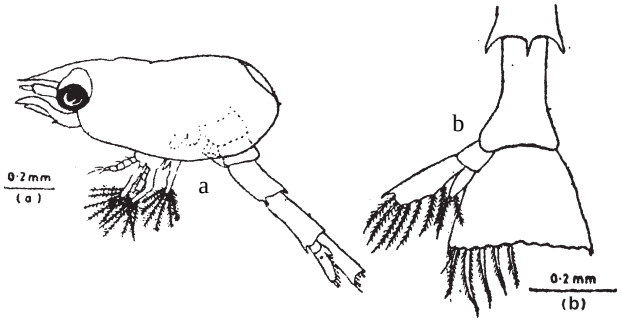

Fig. 4. *Diogenes avarus* Heller 4th zoea (a) Entire larva lateral view (b) Telson and uropod. (Sankolli and Shenoy, 1975).

Glaucothoe: Carapace well developed with cervical groove; rostrum much reduced, rostral scale well developed. Eye stalks long, reaching the last segment of antennular peduncle. Ocular scales serrated distally as in adult (Fig. 5: a, b & c). I **crab instar** (Fig. 6: a, b & c).

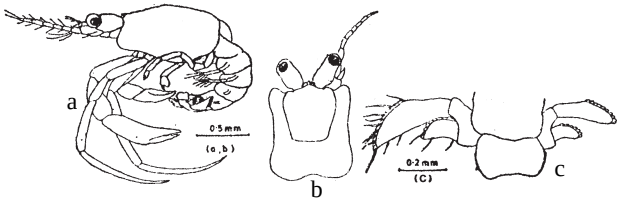

Fig. 5. *Diogenes avarus* Heller Glaucothoe (a) Entire larva lateral view (b) Carapace - anterior part with rostrum. (c) Telson and uropods. (Sankolli and Shenoy, 1975).

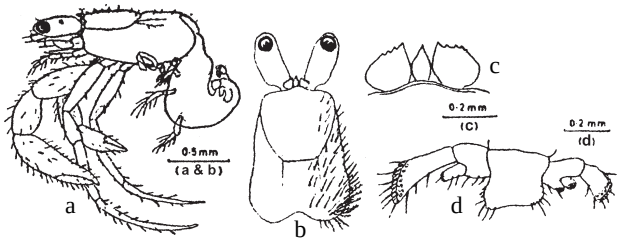

Fig. 6. *Diogenes avarus* Heller 1st crab instar (a) Entire larva lateral view. (b) Carapace - anterior part with rostrum, dorsal view. (c) Carapace - tip. (d) Telson and uropods. (Sankolli and Shenoy, 1975).

Infraorder **BRACHYURA** Latreille, 1802

Section **EUBRACHYURA** de Saint Laurent, 1980

Subsection **HETEROTREMATA** Guinot, 1977

Superfamily **PORTUNOIDEA** Rafinesque, 1815

TRUE CRABS: A large and diverse group in which the carapace is generally dorsoventrally flattened with a defined margin and fused with the ventral plate of the exoskeleton anterior to the mouth, antennae short, the 1st and often the 2nd pair of pereiopods are chaelate, the abdomen reduced and folded under the carapace, typically a wide carapace, with 4-9 anterolateral teeth, paddle like dactyl. (Fig.1. under hermit crab).

Family **PORTUNIDAE** Rafinesque, 1815

Genus ***Scylla***

1. *Scylla serrata* (Forskal): The mangrove or mud crab, carapace width 220 mm, length 140 mm. Carapace with 9 distinctive sharp anterolateral spines of nearly equal size. Cheliped unequal and large with 3 spines on the anterior border. Found in shallow coastal waters with soft substrates, enter mangroves to moult and mate, release eggs in open water. The dorsal spine is bent backwards, lateral spines are closely pressed against the sides of the body, rostral spine is bent over the mouth region in the first zoeal stage. (Fig. 1: a, b & c).

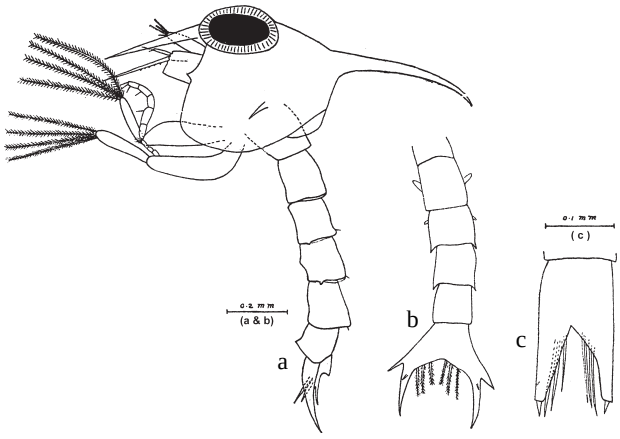

Fig. 1. *Scylla serrata* Forskal (a) Late 1st zoea. (b) Abdomen of the late 1st zoea. (c) Telson of the early 1st zoea. (Naidu, 1965).

Genus ***Thalamita***

2. *Thalamita crenata* Milne-Edwards: Larval stages in portunidae are very much similar creating the process of identification difficult. Hence minor differences are taken into account while differentiating them. **Zoeal** stages from 1 to 5 can be separated from one another by counting the number of natatory setae on the 1st

and 2nd maxillipeds – 4, 6, 8, 10 & 12 setae respectively (Fig. 1: a – i). **Megalopa** also by the number of setation: on the pleopods – 20, 19, 18; on the peduncle of antennules – 5, 4, 2; on the flagellum of the antenna - 0, 0, 3, 2, 4, 2, 3, 2; and on the basal endopodite of maxillule – 20. Crab instar setation of the peduncle of the antennae – 10, 4, 2,; basal endite of maxillule – 19; exopodite of the maxilliped 1:37; endopodite of maxilliped 3:48, 20, 17, 10 and 9 setae.

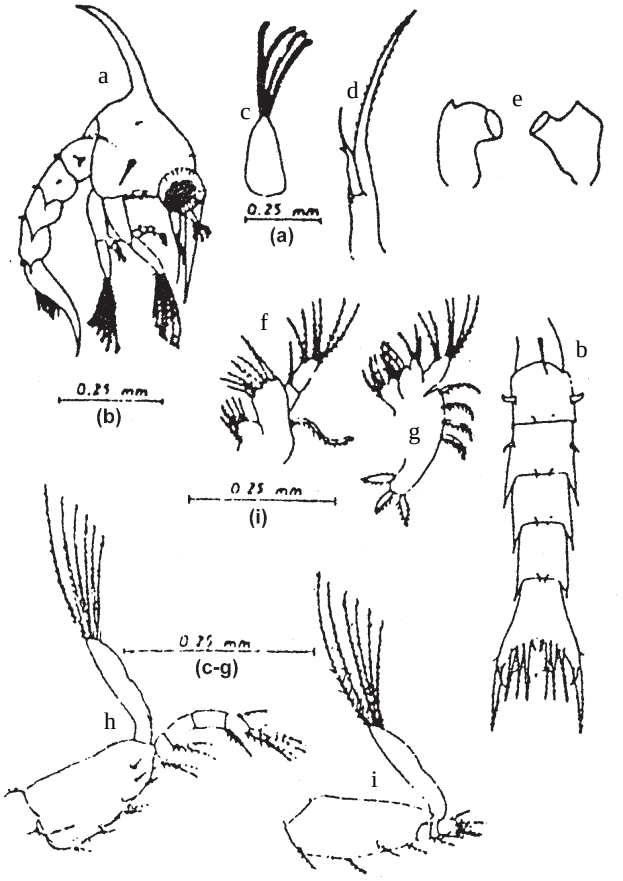

Fig. 1. *Thalamita crenata* Milne-Edwards (a) 2nd zoea lateral view. (b) Abdomen and telson. (c) Antennule. (d) Antenna. (e) Mandibles. (f) Maxillule. (g) Maxilla. (h) 1st maxilliped. (i) 2nd maxilliped. (Krishnan and Kanupandi, 1990).

Superfamily **GRAPSOIDEA** MacLeay, 1838

Family **SESARMIDAE** Dana, 1851

Genus ***Sesarma***

1. *Sesarma lanatum* Alcock: Zoea: Rostral spine 0.20 – 2.46 mm; dorsal spine 0.16 – 0.32 mm; carapace length 0.30 – 0.69 mm; and abdomen length 0.79 – 1.37 mm. **Telson**: Widely forked with a shallow median notch on posterior margin when compared with other species; cornua with 2 rows of spinules; process formula 3+3 (Fig.1: a-i).

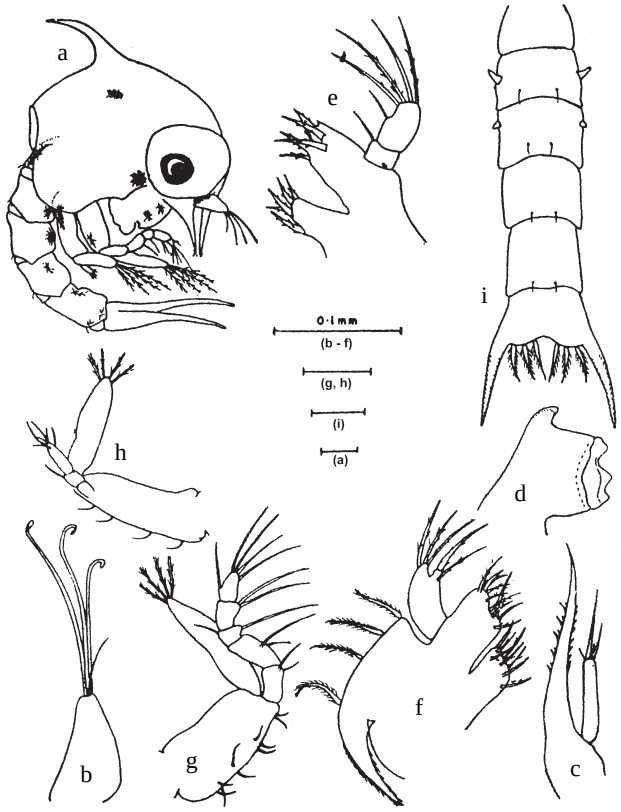

Fig. 1. *Sesarma lanatum* Alcock - 1st zoea (a) Lateral view. (b) Antennule. (c) Antenna. (d) Mandible. (e) 1st maxilla. (f) 2nd maxilla. (g) 1st maxilliped. (h) 2nd maxilliped. (i) Abdomen. (Kakati and Sankolli, 1975).

Megalopa: Carapace smooth with 2 pairs of dorsal humps; frontal region broad and rostrum directed downwards; eyes large. **Telson**: posterior margin smooth without any setae or spines (Fig. 2: a – l). 1st zoea of **S. *lanatum*** differs from the others in the following: a) Antennal exopod with 2 unequal and 2 minute setae as against only 2 setae in the remaining species. b) All abdominal segments smooth except for lateral knobs and dorsal setae unlike in other species. c) **Telson** is more widely forked than in others with a shallower median notch. In megalopa the telson is characteristic with a smooth posterior margin devoid of spines or setae.

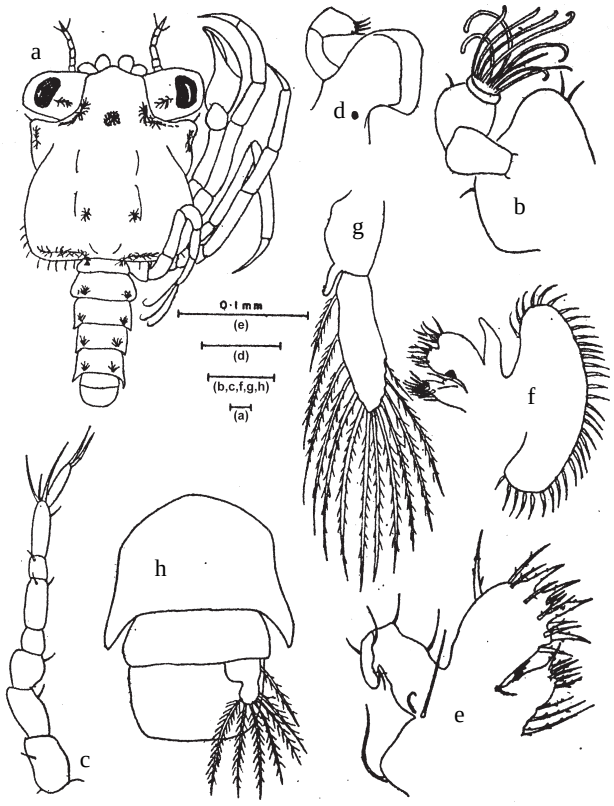

Fig. 2. *Sesarma lanatum* Alcock - Megalopa (a) Dorsal view. (b) Antennule. (c) Antenna. (d) Mandible. (e) 1st maxilla. (f) 2nd maxilla. (g) 1st pleopod. (h) Telson and uropod. (Kakati and Sankolli, 1975).

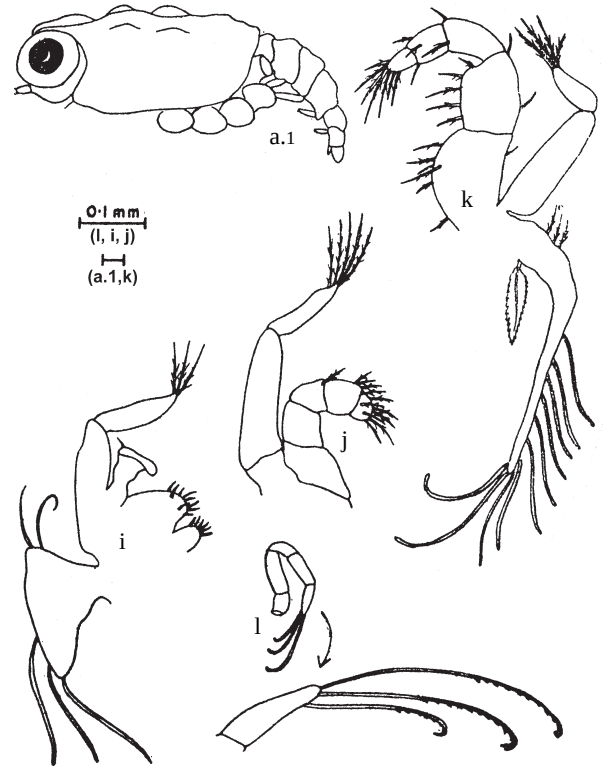

Fig. 2. *Sesarma lanatum* Alcock - Megalopa (a.1) Lateral view. (i) 1st maxilliped. (j) 2nd maxilliped. (k) 3rd maxilliped. (l) 5th pereiopod bud (enlarged view is also given). (Kakati and Sankolli, 1975).

Phylum **CHAETOGNATHA**

Chaetognatha or arrow worms are fast swimmers and voracious predators. Elongated torpedo - like shape, transparent and the head with two eyes, mouth surrounded by chitinous spines, paired lateral fins and an expanded terminal caudal fin. Identification is usually based on teeth, ovaries and seminal vesicles.

Genus ***Sagitta***

1. *Sagitta enflata* Grassi: Origin of anterior fin almost midway between neck and tip of tail, seminal vesicles touching tail fin, anterior teeth 4 to 8; posterior teeth 4 to 13. Ovaries not surpassing origin of anterior fins. It is transparent. Specific character is the anterior fin and the situation of the broadest part of the caudal fin. Reaches 20mm in length mostly between 5 and 10 mm; (Fig.1: a, b, c & d).

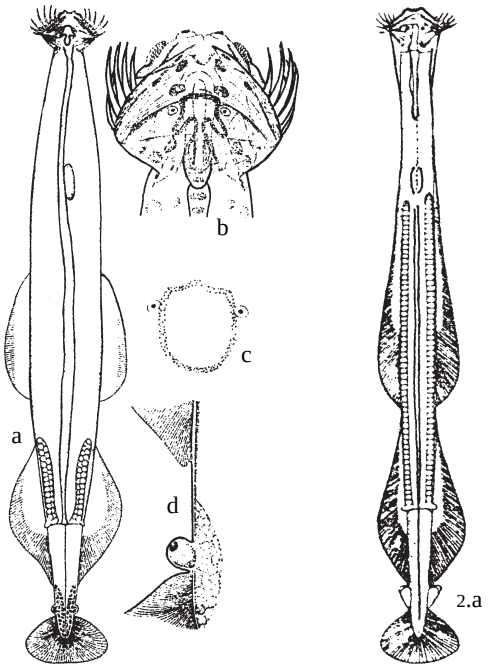

Fig. 1. *Sagitta enflata* Grassi (a) Entire animal dorsal view. (b) Head dorsal view. (c) Simple corona ciliata. (d) seminal vesicle, ventral view.

Fig. 2. *Sagitta bedoti* Beraneck (a) Entire animal dorsal view. (Dakin and Colefax, 1940).

2. *S. bedoti* Beraneck: Intestinal diverticula absent, collarette short, restricted to neck region. Ova arranged in 3 rows. Length 12-14 mm; (Fig. 2: a).

Phylum **CTENOPHORA**

Class **TENTACULATA**

Order **CYDIPPIDA**

Family **PLEUROBRACHIIDAE**

Egg-shaped, 2 cm long. Characteristic feature is the equally spaced 8 longitudinal rows of ciliary plates called comb plates beating successively. Two branched, sticky tentacles, retractile into pockets. Sense organs at one end of body, mouth at the other. Highly transparent.

Genus ***Pleurobrachia***

1. ***Pleurobrachia globosa***: (Fig. 1.a)

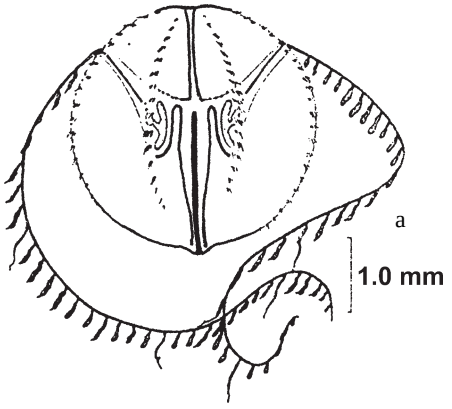

Fig. 1. *Pleurobrachia globosa* (a) Entire animal dorsal view. (Reymont, 1983).

Phylum **ANNELIDA**

Class **POLYCHAETA**

The word polychaeta means many bristles, as the popular name bristle worm suggests. The class includes over 8,000 species of segmented, mostly marine worms belonging to the phylum Annelida. Some species are free swimming. The crawling polychaetes are found among weeds or under stones. Vast populations are burrowing forms on sandy beaches and muddy estuaries, especially in mangroves while others inhabit tubes in sand or encrusted onto stones or rock. Whether the polychaete is free moving (errant) or immobile (sedentary) the body consists of a head bearing paired sensory (antennae) and feeding (palps) appendages followed by a series of bilaterally symmetrical segments. Each segment typically bears a pair of parapodia, the feet like lateral projections usually consisting of bristles or chaetae or setae. Identification can be achieved by examining the basic features of the head, parapodium and chaetae. Illustrations of external morphology and appendages of 4 families of Nereidae, Eunicidae, Terebellidae and Sabellidae are given in Fig.1: a, b, c and d. Cross-sections of parapodia of families Phyllodocidae, Nereididae and Eunicidae in Fig.2: a, b & c. Examples of different types of polychaete chaete are also shown in Fig. 3.a. The larvae of polychaeta are usually planktonic (Fig. 4: a & b).

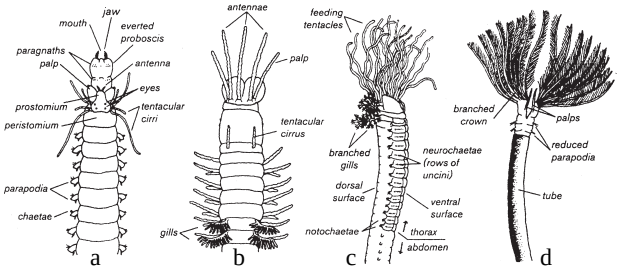

Fig. 1. External morphology and appendages of families. (a) Nereidae dorsal view. (b) Eunicidae dorsal view. (c) Terebellidae lateral view. (d) Sabellidae ventral view. (Richmond, 1997)

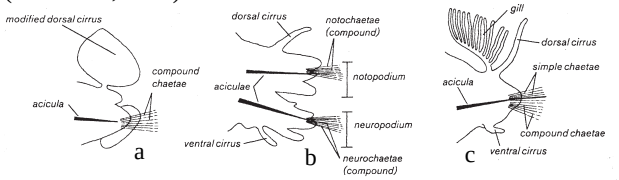

Fig. 2. Diagramatic representations of cross-sections of parapodia of families. (a) Phyllodocidae. (b) Nereididae. (c) Eunicidae. (Richmond, 1997).

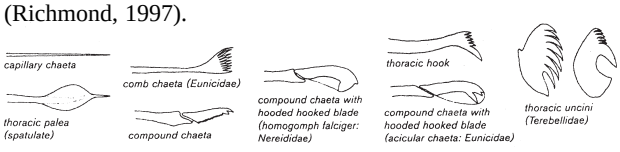

Fig. 3.a. Different types of polychaete chaetae. (Richmond, 1997).

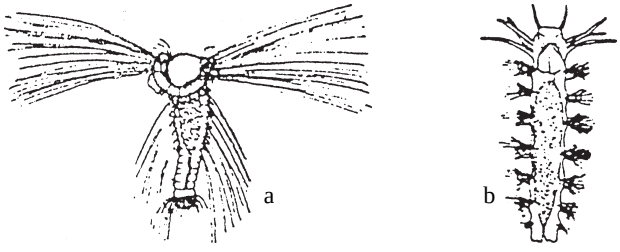

Fig. 4. (a) Spionid larva. (b) Nereid larva. (Wickstead, 1965).

Family **EUNICIDAE**

Genus ***Marphysa***

1. ***Marphysa mossambica*** (Peters): The most common polychaetes of the mangrove ecosystem are those of Eunicidae and Nereidae. ***M. mossambica*** is a typical resident of the mangrove system. Head strongly bilobed; 3 smooth antennae and 2 slender lateral palps, slightly longer than the head, with several annular rings at base. Eyes small. No tentacular cirri. Colour usually dark green with red and black tints. Length 30 to 50 cm; (Fig. 1: a & b).

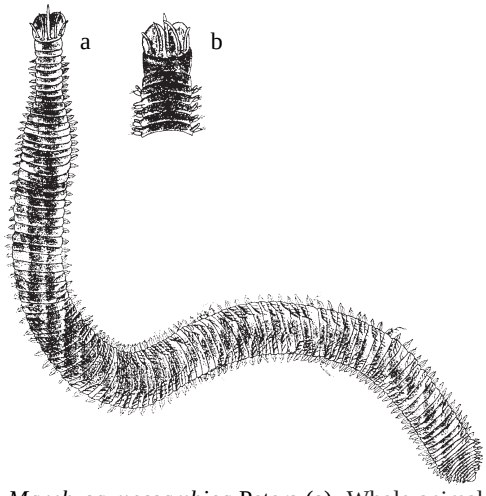

Fig. 1. *Marphysa mossambica* Peters (a) Whole animal dorsal view. (b) Anterior portion. (Richmond, 1997).

Phylum **MOLLUSCA**

Class **PELECYPODA (=BIVALVIA, LAMELLIBRANCHIA)**

Order **VENEROIDA**

Family **VENERIDAE**

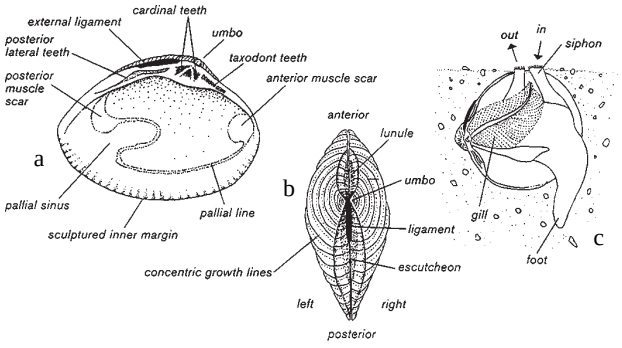

Fig. 1. External characters and morphology of bivalves (a) Inner view. (b) Anterio-posterior view. (c) Section through burrowing bivalve. (Richmond, 1997).

Illustrations on the morphology and external characters of the bivalves are given in Fig. 1: a, b & c).

1. ***Meretrix meretrix*** (Linnaeus): Shell thick, moderately inflated with a variable shape, nearly equilateral or inequilateral; trigonal-ovate in outline. Umbones anterior, poorly inflated. Anterior and ventral margins broadly rounded, posterior end of shell bluntly angled. Lunule smooth and poorly defined. Outer surface of shell smooth, except from low concentric growth marks. Periostracum smooth and glossy. Hinge plate thick, bearing in each valve 3 cardinal teeth and well developed anterior lateral teeth: a strong one in left valve and 2 smaller ones in right right valve. Pallial sinus broad and rather shallow. **Colour**: variable in colour and pattern; interior white fawn to chestnut brown or dark brown along posterodorsal margin. Size: Shell length 6 to 7 cm; (Fig. 1: a & b).

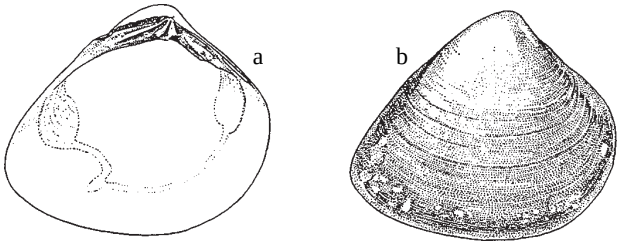

Fig. 1. *Meretrix meretrix* (Linnaeus). (a) Interior of left valve (b) Exterior of right valve. (FAO, 1998).

2. ***Paphia malabarica*** (Chemnitz): The shell is triangularly ovate with moderately inflated valves; smooth or with weak concentric grooves. Thickness moderate. The anterior and posterior margins are narrow and rounded. Shell is shorter and very deeply sculptured with strong close-set concentric ridges which are raised and rounded and not flattened. The separate interstitial grooves are also much deeper. The concentric ridges and grooves are strictly parallel to the margin of the shell. The inner surface of the shell is quite smooth throughout and its margin not diverticulated. Hinge bears 3 short, thick cardinal teeth, the tooth in front of the cardinals in the left valve and the hollow in the right valve are rudimentary. Pallial sinus is moderately deep and

U-shaped. Lunule flattened, narrow and greatly elongated. **Colour**: shell pale yellowish-brown, indistinctly rayed with grayish brown bands; sometimes the surface is elaborately mottled with brownish-angular markings all over (Fig. 2:a).

Fig. 2. *Paphia malabarica* (Chemnitz). (a) External morphology. (Sathyamurthi, 1956).

The larval forms of clams that occur in the collections are mostly veliger stages and cannot be traced to the generic level because of the similarity in appearance (Fig. 3: a, b & c). These are usually found in the mangrove ecosystem.

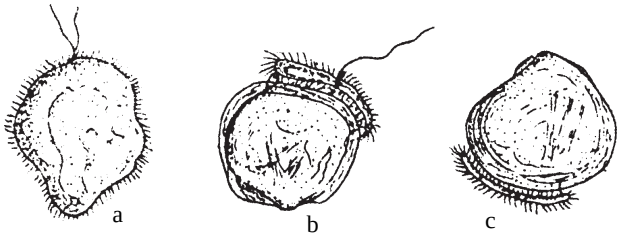

Fig. 3. General pattern of life cycle of clams (a) Trochophore (b) Veliger (c) Spat. (CMFRI).

3. ***Sunetta scripta*** Venus shell or Carpet shell (Linnaeus) : The spat exhibit almost adult characters. Shells solid, thick and equivalve. Ovate in shape with gloosy surface. Umbo more or less rounded. Colour straw yellow or creamy with brown coloured streaks. Cardinal teeth well developed. Two conspicuous muscle scars. Pallial sinus present. Inside shell margin serrated. Habitiat : sandy shores in shallow water.

Sunetta scripta

Order **MYTILOIDA**

Superfamily**MYTILACEAE**

Family **MYTILIDAE**

1. ***Perna viridis*** (Linnaeus): Shell elongate, roughly trigonal-ovate in outline, swollen and pointed anteriorly, rounded and compressed posteriorly. Umbones terminal and sharply tapering. Anterior margin reduced. Ventral margin long and often somewhat concave. Outer surface nearly smooth apart from concentric growth marks and faint radial lines. Periostracum thick and smooth. Hinge with 1 small tooth in right valve and 2 in the left. Anterior adductor

Fig. 1. *Perna viridis* (Linnaeus). (FAO, 1998).

scar absent in adults. Posterior retractor scars large confluent with the posterior adductor scar. Anterior retractor scar separated, elongate-ovate in shape. Internal margins smooth. **Colour:** outside whitish under a bright periostracum which is dark brownish green anteriorly and olive-green to bright green posteriorly. Interior an iridescent pale bluish green with a vivid green margin of periostracum. Size: Shell length 4 to 6.5 cm (Fig. 1).

The spat and plantigrades of this species are encountered in the samples (Fig. 2: a).

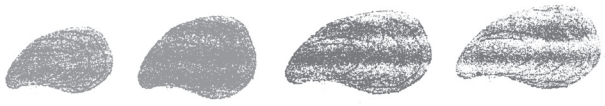

Fig. 2. (a) The Spat and plantigrades of *Perna viridis* (Linnaeus). (CMFRI).

Order **ARCOIDA**

Family **ARCIDAE**

1. ***Villorita cyprinoides*** (Gray): Shelll thick, ovate-triangular with strong concentric ridges which are more strongly developed in anterior half. Umbones prominent and well elevated. Hinge margin short and thick, always with 3 oblique cardinal teeth of which anterior in right valve and posterior in left valve obsolete. Pallial sinus small. Lunule narrow and ligament large. **Colour**: Periostracum dark olive brown to blackish brown (Fig. 1: a).

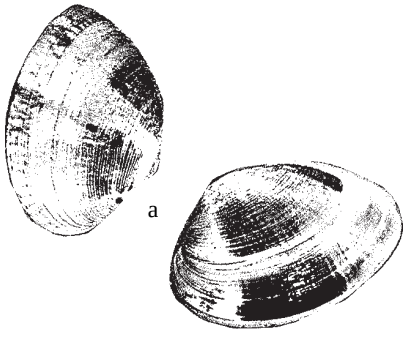

Fig. 1. (a) *Villorita cyprinoides* (Gray). (Sathyamurthi, 1956).

Class **GASTROPODA**

Illustrations on the morphology and external characters of the gastropods are given in Fig.1: a.

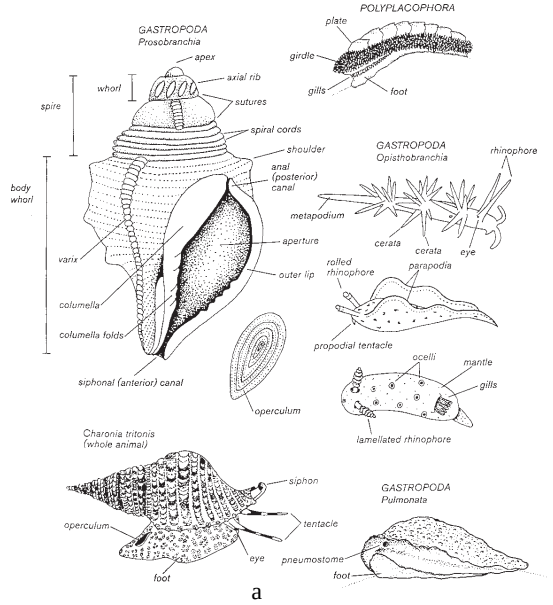

Fig. 1. (a) External morphology of gastropods. (Richmond, 1997).

Order **MESOGASTROPODA**

Family **POTAMIDIDAE**

1. Telescopium (T) telescopium (Linnaeus): Shell large with a high conical spire and a broad rather flat base. Axial sculpture reduced to growth marks. Spire whorls flat sided with weak sutures. 3 large spiral cords and a narrow one alternate with deep spiral grooves. Spiral cords may disappear with age and erosion. Body whorl angulate to strongly rounded on periphery. Aperture obliquely quadrangular and small. Columella twisted with a strong central spiral ridge. Anterior siphonal canal very short, open and strongly twited. **Colour**: outside dark reddish brown to almost black, often with a paler spiral band near the suture. Interior similarly coloured with a light brown or whitish columella. Size: Shell length 5 to 8 cm (Fig. 1: a).

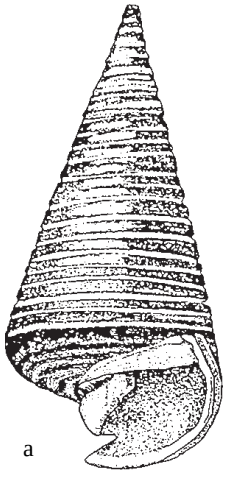

Fig. 1. (a) *Telescopium (T) telescopium* (Linnaeus): Ventral view (FAO, 1998).

2. ***Cerithidea obtusa*** (Lamarck): Shell medium size with a moderately high conical spire and broad rounded base. Spire whorls convex with a moderately deep suture. 6 or 7 rounded spiral cords crossed by stronger, broad axial ridges forming a pattern of more or less sharp nodules. Body whorl wide, rounded at the periphery with axial ridges fading and with 12 to 15 fine spiral cords on the base. Apical part of the spire often gets broken. Aperture wide, subcircular in outline, without a wing-like expansion at posterior end. Outer lip thickened and flared with a tongue-shaped anterior end produced over the

siphonal canal. Columella narrow, posteriorly interrupted without internal spiral ridges. Anterior siphonal canal short, open and oblique. **Colour**: outside shell brown or dull purplish brown, with a brighter zone just below the suture; base plain brown or yellowish dark brown. Size: Shell length 5 to 6 cm; Fig. 2: a).

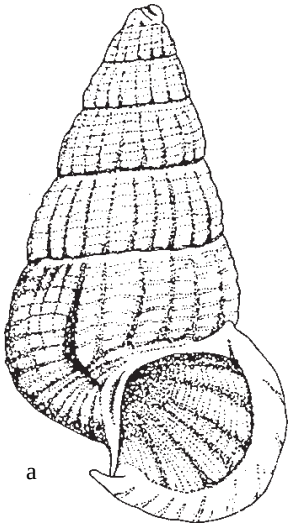

Fig. 2. (a) *Cerithidea obtusa* (Lamarck): Ventral view. (FAO, 1998).

Common in mangrove swamps, on roots and branches above the substrate or on mud tidal banks.

Order **MYOIDEA**

Family **TEREDINIDAE**

Subfamily**BANKIINAE**

Genus ***Nausitoria***

The generic classification of the teredinidae is based on the morphology of soft parts in conjunction with the type of pallets. The pallets are the unique structures located at the base of the siphons to close the burrow when the siphons are withdrawn. The characters of the shell can be useful in a few species but only in conjunction with the pallets because the shells of species belonging to different genera are very similar.

1. *Nausitoria hedleyi* Schepman: Pallets long, feather-like and stalk cylindrical, stout and much shorter than the blade. Outer surface of blade convex, and inner surface flat. The blade is composed of compactly packed segments. Shell large sub-globular with large anterior slope. (Fig. 1: a, b, c & d).

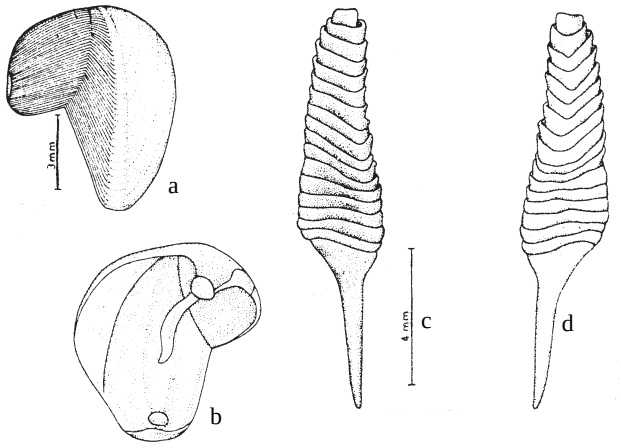

Fig. 1. *Nausitoria hedleyi* Schepman. (a) Outer view of shell. (b) Inner view of shell. (c) Outer view of pallet. (d) Inner view of pallet. (Nair and Salim, 1994).

The genus occurs chiefly in brackish waters and mangrove swamps of tropical and subtropical waters. Most destructive species of shipworms in the brackish water areas of low salinity. The species is found to exist throughout the year but restricted to estuarine conditions.

Genus ***Bankia***

1. *Bankia rochi* Moll: Pallet elongate, solid and calcified with a long, slender and cylindrical stalk, the blade composed of a series of closely to moderately spaced conical segments, each broadly U-shaped. (Fig.1: a, b, c, d, e & f). Found along the east and west coasts of India, especially in Sunderbans, attacks the mangrove trees even in the living condition.

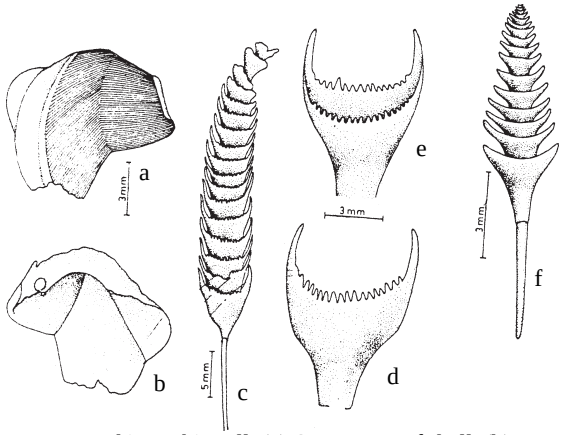

Fig. 1. *Bankia rochi* Moll. (a) Outer view of shell. (b) Inner view of shell. (c) Outer view of pallet. (d, e & f) Inner view of pallet. (Nair and Salim, 1994).

In general, crustacean larvae of several species contribute largely to the abundance of zooplankton observed in the mangrove habitat. The shallow muddy and brackish water environment is thus becomes a paradise of aquatic animals like crustaceans, molluscs and fishes. Some of the crabs like the mangrove or mud crab (*Scylla serrata*), the tree climbing crab *Sesarma* and the fiddler crab *Uca* are the characteristic crustaceans of the environment.

It has been observed that among the seven mangrove centers investigated in Kerala Chettuva displayed the maximum diversity of crustaceans followed next in line by Kumbala and the least in Mangalavanam. All the species of copepods listed whether they are calanoids, harpacticoids, poecilostomatoids or harpacticoids were recorded from this mangrove area. Postlarvae of *Penaeus indicus, Metapenaeus dobson*i and *Acetes erythraeus* occurred frequently in the plankton samples collected from here during April-June and the average number varied from 7-10 /m^3. It is also significant to note that approximately 3-5 crores of postlarvae of *P.indicus* and *M.dobsoni* are collected for aquaculture purposes every year during November –February from Chettuva.

Juveniles of *Penaeus indicus* dominated (209/m^3) the samples collected from Kumbala during the postmonsoon period especially in December and postlarvae of the same species in moderate numbers (10/ $m^{3)}$ during March. Postlarvae of *P.indicus* and *Acetes indicus* also occurred in Koduvally in May and July respectively. The isopod *Cirolana fluviatilis* in Chettuva, the cirripede *Balanus amphitrite* and larval decapods of penaeidae and brachyuridae were observed frequently in abundance at Kujimangalam along with the other crustacean microfauna. The predominant species of the amphipods was *Melita zeylanica* and among the mysids *Mesopodopsis orientalis* and *M. zeylanica* were the common plankters in the mangrove environments of Kerala.

Among the copepods, the harpacticoid *Euterpina acutifrons* occurred throughout the ecosystem. The tanaids were another common mangrove constituent that appeared in large numbers especially during the monsoon season in the mangroves. *Tanais philetaerus* or *Apseudes chilkensis* or both occurred together and especially at Kumbala the total concentration of the tanaids was the highest (126/m^3) during June-July.

It can be safely concluded from the present investigations on mangroves of Kerala that there is great potential for the crustacean microfauna of economic importance from certain centres particularly Chettuva, Kumbala and Kunjimangalam and can be harvested yearly if proper conservation measures are taken in time to prevent depletion. As such studies on mangroves are conducted with a view to give guidelines for sustainable, multipurpose-use management of the ecosystem.

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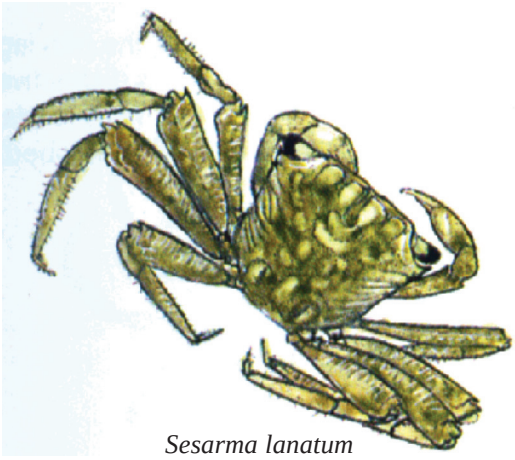
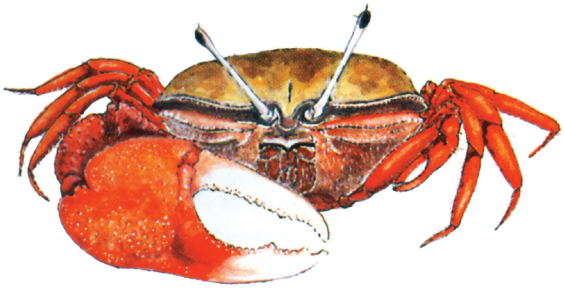
Scylla serrata - mangrove crab



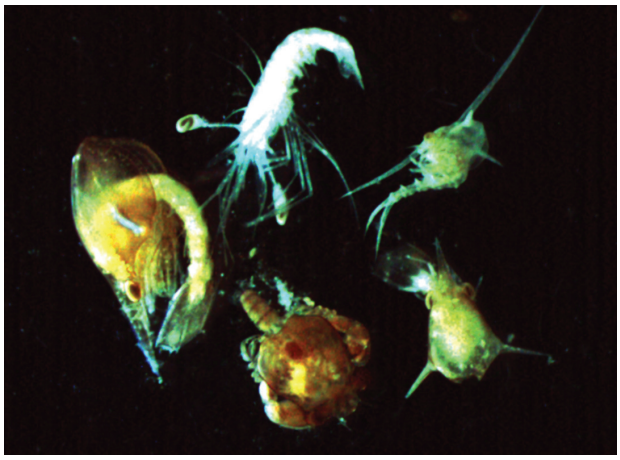
Sesarma lanatum

Thalamita crenata

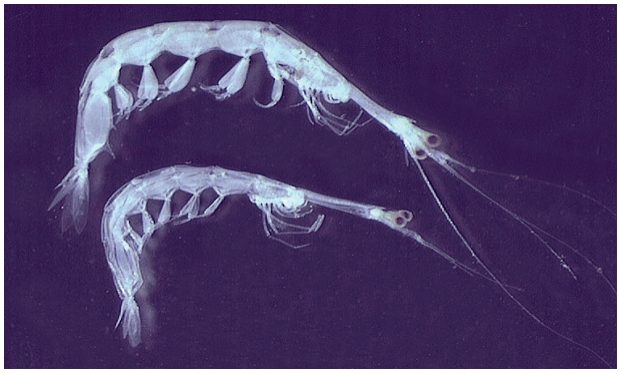


Uca sp.

Common crabs of the mangrove ecosystem



Decapod larvae

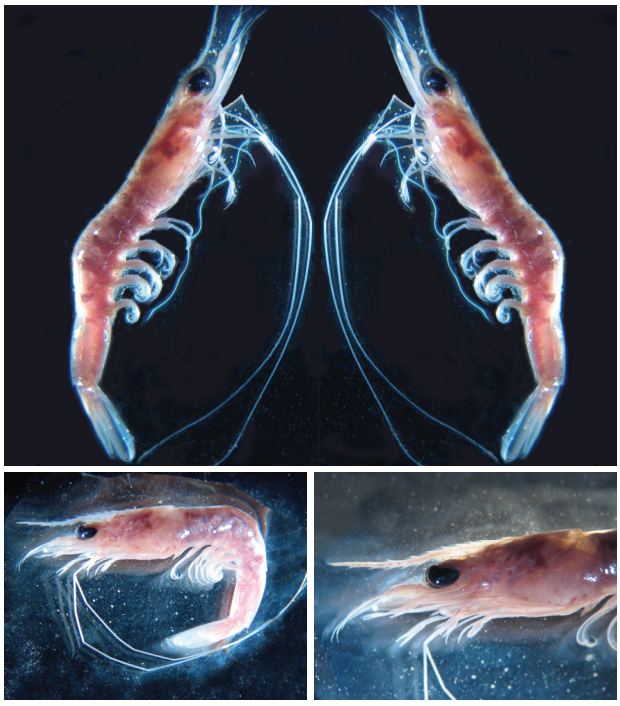


Lucifer hanseni

Pseudodiaptomus annandalei

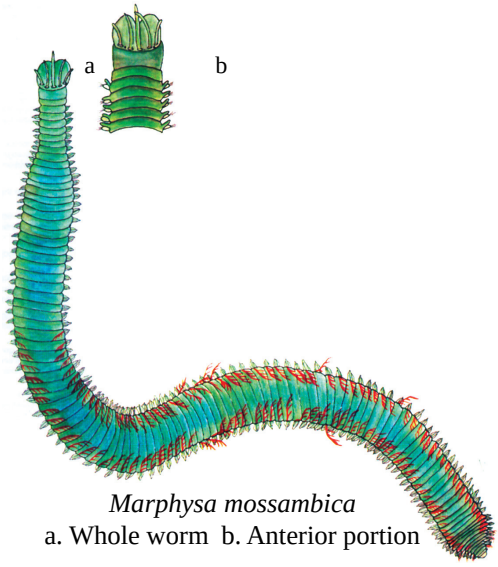
Pseudodiaptomus serricaudatus

Common zooplankton of the mangrove ecosystem

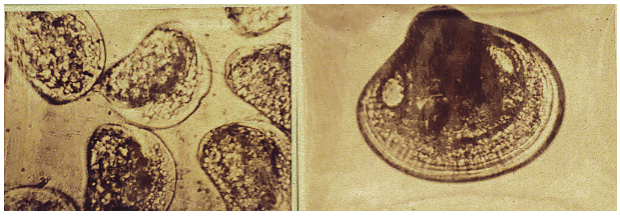


Juveniles of *Penaeus indicus*

Cirolana fluviatilis



Marphysa mossambica
a. Whole worm b. Anterior portion



Spat stages bivalves

Perna viridis

Meretrix meretrix

Paphia malabarica